WISCONSIN STATE ELECTRICAL CODE

Volume No. 2

Electrical and Communication Equipment and Lightning Protection

Fifth Edition

Revised to
(July 25, 1951)

Compiled by
Industrial Commission of Wisconsin
and
Public Service Commission of Wisconsin

Volume No. 1: Electrical and Communication Lines and Supply Stations.

Contains orders covering the following:

General Requirements, Definitions and Grounding of Electrical Facilities	Introduction
Electrical Supply Stations and Substations	Part 1
Supply and Communication Lines	Part 2
Operation of Electric and Communication Equipment and Lines	Part 4

Volume No. 2: Electrical and Communication Equipment and Wiring and Lightning Protection.

Contains orders covering the following:

General Requirements and Definitions	Introduction
Electrical and Communication Equipment and Wiring Including Grounding	Part 3
Protection of Buildings and Structures Against Lightning	Part 6

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Volume No. 2

WISCONSIN STATE ELECTRICAL CODE

The complete code (Volumes 1 & 2) covers the minimum fire and safety requirements for the construction and installation of all electrical, communication, and signal circuits and equipment including radio and lightning rod equipment; and rules to be observed in the operation of electric and communication equipment and lines.

FIFTH EDITION

Revised to
(July 25, 1951)

Madison, Wisconsin

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BEFORE THE

PUBLIC SERVICE COMMISSION OF WISCONSIN

In the Matter of the Revision by the Commission of the Rules and Regulations Governing the Construction, Operation, and Maintenance of Lines and Equipment Owned, Managed, Operated, or Controlled by Every Public Utility and Every Railroad Along or Across any Public Highway or Private Right of Way over which Electrical Energy is Transmitted, or Messages are Transmitted or Conveyed. } U–2776

ORDER APPROVING ELECTRICAL CODE

WHEREAS copies of Volume 2 of the fifth edition of the code as adopted August 30, 1944; November 21, 1944 and amended February 25, 1949 have become exhausted and changes in material and methods have made it desirable to revise both volumes of the code; and

WHEREAS a joint investigation has been conducted by the Industrial Commission of Wisconsin and the Public Service Commission of Wisconsin involving the revision of the standards of safe electrical construction and operation; and

WHEREAS all railroads and public utilities under the jurisdiction of this Commission and subject to the requirements of Chapters 195 and 196 of the Statutes have had due notice of the hearing held in connection with the aforesaid investigation; and

WHEREAS as a result of such investigation certain changes in, and additions to, the Wisconsin State Electrical Code have been adopted and promulgated by the Industrial Commission of Wisconsin as their General Orders Nos. 1000 to 1452 and 1600 to 1652 inclusive, effective July 25, 1951, as more particularly shown in said code;

FINDING

THE COMMISSION FINDS:

That the requirements set forth in the order herein made are proper and necessary to be prescribed for the railroads and public utilities of this state.

ORDER

IT IS THEREFORE ORDERED:

(1) That all railroads and public utilities subject to the jurisdiction of this Commission and subject to the requirements of Section 196.74 be and are hereby required to observe and conform to the

standards of construction, maintenance, and rules of operation as established by the Wisconsin State Electrical Code adopted by the Industrial Commission, which is hereby approved and adopted as an order of this Commission.

(2) That to make the latest code available to the public.

a. Volume 2 of the fifth edition shall be reprinted and shall contain all revisions to the date of this order.

b. A supplement to Volume 1 of the fifth edition shall be printed containing all changes made since November 1944 to the date of this order.

Dated at Madison, Wisconsin, this 25th day of July, 1951.

PUBLIC SERVICE COMMISSION OF WISCONSIN

JOHN C. DOERFER
Chairman

JAMES R. DURFEE
Commissioner

W. F. WHITNEY
Commissioner

WISCONSIN STATE ELECTRICAL CODE

Preface

By Chapter 101 of the revised statutes, it is the duty of the Industrial Commission to fix standards of safety in all places of employment and to formulate rules and regulations relative to the enforcement of such standards. It is further the duty of the Industrial Commission to fix similar standards and formulate rules and regulations relating to fire hazards or to the prevention of fires in buildings so situated as to endanger other buildings or property.

The first electrical code was adopted in 1917. Between 1917 and the present date, the 1917 code orders were revised and changed a number of times.

The first printing of the fifth edition contained some orders which became effective August 30, 1944 and some that became effective December 21, 1944. Certain amendments became effective February 25, 1949.

The fifth edition was the first code that was printed in two volumes to accommodate various interests who use some parts of the code to the exclusion of others. When reference is made to the Wisconsin State Electrical Code, both volumes are meant.

Because copies of volume 2 of the code became exhausted and new materials and methods have become available, it was decided to reprint and revise volume 2 and to print a supplement for volume 1.

The following committee representing the organizations noted, together with the advisors given below, met with representatives of the Industrial and Public Service Commission at various times to formulate recommendations to be presented to the Commission.

CODE COMMITTEE

John E. Wise, Madison, Chairman of Committee, Industrial Commission of Wisconsin.

R. E. Purucker, Madison, Secretary of Committee, Public Service Commission.

J. A. Dickinson, Washington, Bureau of Standards.

W. A. Haig, Milwaukee, Milwaukee Building Inspection Department.

George C. Cooper, West Allis, Wisconsin Manufacturers' Association.

L. A. Wood, Chicago, Association of American Railroads.

E. J. Kallevang, Madison, Wisconsin Utilities Association.

B. H. Barg, Milwaukee, Electrical Contractors' Association.

J. B. Wilkinson, Milwaukee, Fire Insurance Rating Bureau.
Wm. Harnack, Wauwatosa, Wisconsin State Federation of Labor.
G. W. Searle, Milwaukee, Wisconsin Telephone Company.
Orville R. Nichols, Milwaukee, Wisconsin Electrical Association.
C. T. Evans, Milwaukee, Electrical Utilization Equipment Manufacturers.
Herman P. Siebkin, Madison, State Telephone Association.

The persons consulted as technical advisors were:

G. A. Benjamin, Minneapolis, Western Union Telegraph Company.
Walter Gerke, Milwaukee, Wisconsin State Federation of Labor.
W. E. Gundlach, Milwaukee, Wisconsin Electric Power Company.
E. H. Herzberg, Milwaukee, Manager Electrical Contractors' Association, Milwaukee Chapter.
R. C. Siegel, Milwaukee, Wisconsin Telephone Company.
C. L. Smith, Chicago, Electrical Field Engineer, National Fire Protection Association.
W. S. Wilder, Milwaukee, Wisconsin Electric Power Company.
H. E. Reinhold and L. W. Butler, Milwaukee, Wisconsin Telephone Company.

The formal hearing was held at Milwaukee on January 12, 1951, at which time the committee's report was submitted to the two commissions. Following the hearing the committee considered certain questions raised at the hearing and made recommendations to the commissions. The committee's recommendations and other suggestions were considered fully and the Industrial Commission's action was published in the official state paper on June 25, 1951, and hence became effective thirty days later, namely, July 25, 1951. The Public Service Commission's order became effective as of the same date.

LOCAL ELECTRICAL REGULATIONS

Section 101.16 subsection 1 of the statutes provides that when any orders of the Industrial Commission have been filed with the clerk of any village or city it then becomes the duty of local officers to enforce such orders and thereafter no local officer shall make or enforce any order contrary to such orders.

However, nothing in this Electrical Code shall be understood to limit the power of any town, village or city to enact and enforce additional or more stringent local regulations, provided the same do not abridge or conflict with this code or any other orders of the Industrial Commission. The State Electrical Code sets forth the minimum construction requirements for the entire state, but where local regulations are more stringent, in whole or in part, the additional local requirements must also be met.

Less stringent local regulations are held to be amended or modified by similar orders of the Industrial Commission.

Statutes Affecting Interior Wiring, Transmission Lines, etc.

Section 167.16 of the Statutes requires the following regarding electric wiring.

> Regulation of Electric Wiring. 167.16(1) It is hereby made the duty of every contractor and other person who does any electric wiring in this state to comply with the Wisconsin State Electrical Code, and the company furnishing the electrical current shall obtain proof of such compliance before furnishing such service; provided, that nothing therein contained shall be construed as prohibiting any municipality from making more stringent regulations than those contained in the above mentioned code. Proof of such compliance shall consist of a certificate furnished by a municipal or other recognized inspection department or officer, or if there is no such inspection department or officer it shall consist of an affidavit furnished by the contractor or other person doing the wiring, indicating that there has been such compliance.
>
> (2) Any person who shall violate the provisions of this section shall be deemed guilty of a misdemeanor and shall be punished by a fine of not less than twenty-five dollars nor more than one hundred dollars, or by imprisonment in the county jail not less than thirty days nor more than six months.

The following forms of affidavit, one form for the contractor and one for the electrical inspector, are suggested:

SUGGESTED FORM OF AFFIDAVIT TO BE USED BY ELECTRICAL INSPECTOR

State of Wisconsin }
_____ County }
City } _____ } ss
Village }
Town }

I, _____, do hereby certify that I am the duly appointed, qualified and acting electrical inspector of said city, village or town; that I have inspected the following described electric wiring installed by, _____, on the premises occupied by _____, and located at No. _____ Street, in said city, village or town, and that said wiring complies with the Wisconsin State Electrical Code. Description of wiring inspected, _____

Dated _____, 19____

_____
Electrical Inspector

SUGGESTED FORM OF AFFIDAVIT TO BE USED BY ELECTRICAL CONTRACTOR

STATE OF WISCONSIN }
County of _____ } ss

_____, being duly sworn by oath, says that he is the person who *_____ the following described work of wiring for electricity in the **_____, occupied by _____, and located ***_____ in the County of _____, Wisconsin, and that all of said described electric wiring at the location above was done so as to comply, and does comply, with the Wisconsin State Electrical Code, and that this affidavit is made pursuant to and in compliance with the provisions of section 167.16 of the Statutes.

Description of wiring done _____

_____

(Signed) _____

Subscribed and sworn to before me, this _____ day of _____, 19___.

_____

Notary Public, _____ County, Wis.

Section 196.72(1) of the Statutes requires

> (1) Every public utility shall immediately report to the Commission (i.e. Public Service Commission) every fatal accident occurring upon its premises or directly or indirectly arising from or connected with its maintenance or operation.

Section 102.37 of the Statutes requires

> Every employer of three or more persons and every employer who is subject to the workmen's compensation act shall keep a record of all accidents causing death or disability of any employee while performing services growing out of and incidental to the employment, which record shall give the name, address, age and wages of deceased or injured employee, the time and causes of the accident, the nature and extent of the injury, and such other information as the Industrial Commission may require by general order. Reports based upon this record shall be furnished to the Industrial Commission at such times and in such manner as it may require by general order upon forms to be procured from the Commission (i.e. Industrial Commission).

In connection with Section 102.37 of the statutes quoted above, the Industrial Commission has issued the following rule 2 of its "Rules of Practice of Industrial Commission of Wisconsin."

> Employers under the provisions of the workmen's compensation act within one day after the fatal termination of an accident or industrial disease, shall make a brief report of this occurrence to the Industrial Commission by telegraph or by letter. They shall also make a report on Form A–12 on the fourth day after the accident or beginning of disability from occupational disease upon every accident or disease causing death or a disability which exists beyond the third day after the employee leaves work as a result of the accident.
>
> Self-insured employers and insurance companies on all accidents which require a first report must:
>
> 1. Make a supplementary report on Form A–13 on the eleventh day following that on which the accident occurred.
>
> 2. Make another supplementary report immediately when payments are stopped for any reason. This report must be accompanied by an explanatory memorandum, if there is a dispute with the injured man.
>
> 3. Make a final report on Form A–13 when final payment of compensation has been made, which must be accompanied by (a) a copy of the final receipt signed by the injured employee; and (b) a report from a physician, if the disability exceeds three weeks or if there is any permanent disability, unless there has been a hearing before the Commission.
>
> 4. Supply to the employe copy of final report on Form A–13 in all cases at the time of final payment, and final physician's report in cases where disability has extended beyond three weeks following the date of injury, or where permanent disability has resulted.
>
> 5. Make immediate report of any amputation which requires an artificial member or appliance.

* Space left for the word "did" or "supervised." ** Specify residence, barn or other building in which wiring was done. *** In villages and cities insert street and number and name of city or village. In unincorporated territory insert section number and name of town.

Some of the other laws that have a bearing on electric construction and safety are as follows:

Section or Chapter Laws of 1949	*Subject Matter*
Chapter 101	Creation and duties of Industrial Commission
Chapter 102	Workmen's compensation act
Chapters 195 and 196	Creation and duties of Public Service Commission
Section 86.16	Poles on highways
Section 180.17	Transmission lines
Section 180.18	Wires over railroads
Section 196.171	Examination of meters, pipes, fittings, wires and works; entering buildings for
Section 180.19	Damages for non-delivery of message
Section 196.67	Transmission lines and warning signs
Section 196.74	Safety and interference
Sections 343.17 and 98.25	Diversion of current
Section 343.175	Fraudulent use of gas, electricity, water and steam
Section 343.724	Poles on private property
Section 343.43	Injury to property
Section 348.38	Injury to wires

The above is not a complete list of laws covering all the subject matter involved nor all the laws administered by the Public Service Commission and Industrial Commission.

Other Industrial Commission Publications

Flammable Liquids Code
Building Code
Elevator Code
Boiler Code
Industrial Lighting Code
School Lighting Code
Refrigerator Code
Heating and Ventilating Code
Cleaning and Dyeing Code
General Orders on Existing Buildings
General Orders on Dusts, Fumes, Vapors and Gases
General Orders on Safety in Construction
General Orders on Fire Prevention
General Orders on Sanitation
General Orders on Safety
General Orders on Spray Coating
General Orders on Quarries and Pits
General Orders on Mines
General Orders on Tunnel, Caisson and Trench Construction
General Orders on Explosives
General Orders on Electrical Fences
General Orders on Liquefied Petroleum Gases.

Enforcement

The authority for the enforcement of this code is vested in the Public Service Commission with respect to the installation and operation of circuits or equipment by public utilities in the exercise of their functions as utilities; and in the Industrial Commission with respect to the installation and operation of circuits or equipment affecting employees, employers, or the public.

INTRODUCTORY PART

VOLUME 2

GENERAL REQUIREMENTS AND DEFINITIONS

Order 1000. Scope of Code.

This code, consisting of two volumes, shall apply as minimum fire and safety requirements for the construction, installation, and maintenance of all electrical and communication circuits and equipment including signal, radio, and lightning rod equipment; and includes rules to be observed in the operation of electrical and communication equipment and lines.

SECTION 101. GENERAL REQUIREMENTS

Order 1010. Character of Construction, Maintenance and Operation.

All electrical and communication equipment and lines shall be of such construction, and so installed, operated, and maintained as to minimize the life and fire hazard.

Order 1011. Use of Approved Materials and Construction Methods.

A. *Materials.* No materials, employed in construction covered by this code, shall be used which have not been approved by the Industrial Commission or Public Service Commission.

Exception: Materials which comply with the requirements of this code are hereby approved.

Note: It is the policy of the administrative authority to approve materials, devices, and systems which are listed as standard by the Underwriters' Laboratories if they do not conflict with the requirements of this or other state codes or the laws of the state.

B. *Methods of Installation.* No methods of installing electrical materials or devices in construction covered by this code shall be used which are not approved by the Industrial Commission or Public Service Commission.

Exception: Methods of installation which comply with the requirements of this code are hereby approved.

Order 1012. Construction, Inspection and Repairs.

All construction and equipment shall be cleaned when necessary and inspected at such intervals as experience has shown to be necessary. Any equipment or construction known to be defective so as to endanger life or property shall be promptly repaired, permanently disconnected, or isolated until repairs can be made. Construction, repairs,

additions and changes to electrical equipment and conductors shall be made by qualified persons only. (See also Orders 1211 and 1213.)

Order 1013. Application of Orders.

A. *Waiving Orders.* The orders are intended to apply to all installations except as modified or waived by the proper administrative authority. They are intended to be so modified or waived in particular cases wherever any rules are shown for any reason to be impracticable, such as by involving expense not justified by the protection secured; or if equivalent or safer construction is secured in other ways.

B. *Application.* The intent of the orders will be realized (1) by applying the orders in full to all new installations, reconstructions, alterations, and extensions, except where any rule is shown to be impracticable for special reasons or where the advantage of uniformity with existing construction is greater than the advantage of construction in compliance with the orders, providing the existing construction is reasonably safe; (2) by bringing existing installations into conformity with these orders as far as may be directed by the Industrial Commission or Public Service Commission and within the time determined by them.

C. *Penalties.* The 1949 Statutes of the State of Wisconsin require:

> 102.57 Where injury is caused by the failure of the employer to comply with any statute or any lawful order of the Commission, (i.e. Industrial Commission) compensation and death benefits as provided for in this chapter shall be increased fifteen percent.
>
> 102.58 Decreased compensation. Where injury is caused by the wilful failure of the employe to use safety devices where provided in accordance with any statute or lawful order of the commission and adequately maintained, and their use is reasonably enforced, by the employer, or where injury results from the employee's wilful failure to obey any reasonable rule adopted by the employer for the safety of the employe and of which the employe has notice, or where injury results from the intoxication of the employe, the compensation, and death benefit provided herein shall be reduced 15 per cent.
>
> 196.64 Utilities, liability for treble damages. If any public utility shall do or cause to be done or permit to be done any matter, act or thing prohibited or declared to be unlawful by chapter 196 or 197, or shall omit to do any act, matter or thing required to be done by it, such public utility shall be liable to the person injured thereby in treble the amount of damages sustained in consequence of such violation.
>
> 196.66 General penalty; utility responsible for agents. (1) If any public utility shall violate any provision of chapter 196 or 197, or shall do any act therein prohibited or shall fail or refuse to perform any duty enjoined upon it for which a penalty has not been provided, or shall fail, neglect or refuse to obey any lawful requirement or order made by the Commission (i.e. Public Service Commission) or the municipal council or any judgment or decree made by any court upon its application, for every such violation, failure or refusal such public utility shall forfeit not less than twenty-five dollars nor more than one thousand dollars.
>
> (2) Every day during which any public utility or any officer, agent or employee thereof shall fail to observe and comply with any order or direction of the Commission or to perform any duty enjoined by chapter 196 or 197, shall constitute a separate and distinct violation.

D. *Temporary Installations.* It will sometimes be necessary to modify or waive certain of the orders in case of temporary installations or installations which are shortly to be dismantled or reconstructed. Such temporary construction may be used for a reasonable length of time provided it is under competent supervision while it or adjoining equipment is alive or if it is protected by suitable barriers or warning signs when accessible to any person, without fully complying with this code; but all such construction shall be made reasonably safe.

E. *Testing.* Rooms which are used exclusively for routine or special electrical test work and, therefore, are under the supervision of a qualified person, need comply with this code only insofar as is practicable for the character of the testing done.

F. *Emergency.* In case of emergency or pending decision of the administrator, the person responsible for the installation may decide as to modification or waiver of any order, subject to review by proper authority.

SECTION 102. DEFINITIONS OF SPECIAL TERMS

Order 1020. Definitions.

The following is a list of terms which it was deemed advisable to define. Terms defined only in Volume 1 are indicated. Terms not defined will be understood to have their customary meaning.

Accessible (as applied to wiring methods) means not permanently closed in by the structure or finish of the building, capable of being removed without disturbing the building structure or finish; (as applied to equipment) admitting close approach because not guarded by locked doors, elevation or other effective means. (See also "Readily Accessible.")

Administrative Authority means the Industrial and/or the Public Service Commissions.

Alive or Live means electrically connected to a source of potential difference, or electrically charged so as to have a potential different from that of the earth. The term "live" is sometimes used in place of the term "current-carrying" where the intent is clear, to avoid repetitions of the longer term.

Antenna Conflict. See Volume 1.

Appliance means current-consuming equipment, fixed or portable; for example heating, cooking and small motor-operated equipment.

Approved means acceptable to the administrative authority enforcing this code. (See Order 1011).

Armored Cable means flexible metallic tubing in which the conductors have been inserted in the process of manufacture.

Askarel means a synthetic non-flammable insulating liquid which, when decomposed by the electric arc, evolves only non-explosive gases.

Authority. See Administrative Authority.

Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influences as, for example, a change in current strength; not manual; without personal intervention. Remote control that requires personal intervention is not automatic, but manual.

Branch Circuit means that portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

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

Building means a structure which stands alone or which is cut off from adjoining structures by unpierced fire walls. (See Building Code).

Cabinet means an enclosure designed either for surface or flush mounting, and provided with a frame, mat or trim in which swinging or sliding doors are placed. (See cutout box).

Cable means a combination of conductors which are bound together and insulated from each other. It also includes single conductors having the same insulation and outside protective covering as commonly used in multi-conductor cables.

Cable Vault. See Manhole.

Circuit means a conductor or system of conductors through which an electric current is intended to flow.

Circuit-breaker means a device designed to open under abnormal conditions a current-carrying circuit without injury to itself. The term as used in this code applies only to the automatic type designed to trip on a predetermined overload of current.

Climbing Space. See Volume 1.

Common Use. See Volume 1.

Communication Lines. See Volume 1.

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

Conductor:

Conductor means a metallic conducting material, usually in the form of a wire or cable, suitable for carrying an electric current.

Grounding Conductor means a conductor which is used to connect the equipment or the wiring system with a grounding electrode or electrodes.

Lateral Conductor means, in pole wiring work, a wire or cable extending in a general horizontal direction approximately at right angles to the general direction of the line conductors.

Line Conductor means one of the wires or cables carrying electric current, supported by poles, towers, or other structures, but not including vertical or lateral connecting wires.

Vertical Conductor means, in pole wiring work, a wire or cable extending in an approximately vertical direction.

Conductor Conflict. See Volume 1.

Conduit:

Conduit means a tube especially constructed for the purpose of enclosing electrical conductors.

Rigid Metal Conduit means a tubular raceway with threaded ends, for electric wires and cables; if of ferrous metal, having a corrosion resistant coating on all surfaces, except threads and if of corrosion resistant material, properly identified and in either case with a uniformly smooth interior coating of enamel or like material. Conduit may be made of mild steel tubing of circular cross-section having walls which in the various electrical trade sizes comply with the measurements and weights set forth in Order 13–93461. For other materials dimensions are to be the same and weights will vary.

Flexible Metallic Conduit means a flexible raceway of circular cross section especially constructed for the purpose of permitting drawing in or withdrawing of wires and cables after the conduit and its fittings are in place, and is made of metal strip, usually of steel with metallic corrosion resistant coating, helically wound and with interlocking edges.

Electrical Metallic Tubing means a thin-walled steel or corrosion resistant metal raceway of circular cross-section, constructed for the purpose of pulling in or withdrawing wires after it is installed in place, coated inside and out to be corrosion resistant and connected by means of threadless fittings. The interior diameters should be the same as for the corresponding trade sizes of rigid conduit. See Section 13–348 and Order 13–93481.

Conflict. See Volume 1.

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

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

Current-carrying Part means a conducting part intended to be connected in an electric circuit. Non-current-carrying parts are those not intended to be so connected.

Cutout Box means an enclosure designed for surface or flush mounting and having swinging or sliding doors or covers secured directly to and telescoping with the walls of the box proper. (See Cabinet).

Dead means free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth. The term is used only with reference to current-carrying parts which are sometimes alive.

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

Device means a unit of an electrical system which is intended to carry but not consume electrical energy.

Disconnector means a switch which is intended to open a circuit after the load has been thrown off by some other means.

Note: Manual switches designed for opening loaded circuits are usually installed in circuit with disconnectors, to provide a safe means for opening the circuit under load.

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

Duct means (in underground work) a single tubular runway for underground cables.

Dustproof means so constructed or protected that an accumulation of dust will not interfere with its successful operation.

Dusttight means so constructed that dust will not enter the enclosing case.

Duty:

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

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

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

Short-Time. Short-time duty is a requirement of service that demands operation at a substantially constant load for a short and definitely specified time.

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

See table in Order 13–4312 for illustrations of various types of duty.

Effectively Grounded. See Grounded.

Electrical Metallic Tubing. See Conduit.

Electrical Supply Equipment. See Equipment.

Electrical Supply Lines. See Lines.

Electrical Supply Station means any building, room, or separate space within which electrical supply equipment is located and the interior of which is accessible, as a rule, only to properly qualified persons.

This includes generating stations and substations and generator, storage battery, and transformer rooms, but excludes manholes and isolated transformer vaults on private premises. (See definition of "Transformer Vault").

Electric Sign means a fixed or portable, self-contained electrically illuminated appliance with words or symbols designed to convey information or attract attention.

Enclosed means surrounded by a case which will prevent accidental contact of a person with live parts. A solid enclosure means one which will neither admit accumulation of flyings or dust nor transmit sparks or flying particles to the accumulations outside.

Equipment:

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

Electrical Supply Equipment means equipment which produces, modifies, regulates, controls, or safeguards a supply of electrical energy.

Utilization Equipment means equipment, devices, and connected wiring, which utilize electrical energy for mechanical, chemical, heating, lighting, testing, or similar purposes and are not a part of supply equipment, supply lines or communication lines.

Explosion-proof means enclosed in a case which is designed and constructed to withstand an explosion of a specified gas or dust which may occur within it, and to prevent the ignition of the specified gas or dust surrounding the enclosure, by sparks, flashes or explosions of the specified gas or dust which may occur within the enclosure.

Exposed:

Exposed (applied to circuits or lines) means in such a position that in case of failure of supports or insulation contact with another circuit or line may result.

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

Exposed (as applied to wiring methods) means accessible; not concealed.

Externally Operable means capable of being operated without exposing the operator to contact with live parts. (This term is applied to equipment, such as a switch, that is enclosed in a case or a cabinet).

Feeder means any conductors of a wiring system between the service equipment, or the generator switchboard of an isolated plant, and the branch circuit over-current device.

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

Flexible Metallic Tubing. See Conduit.

Garage:

Garage means 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 on which such vehicles are kept and which is not separated therefrom by tight, unpierced fire walls and fire-resistive floors.

Commercial (Public) Garage means any building where self-propelled vehicles are sold or serviced, or where three or more such vehicles are stored or serviced for hire or for commercial use.

General-use Switch. See Switch.

Grounded:

Grounded means connected to earth or to some extended conducting body which serves instead of the earth, whether the connection is intentional or accidental.

Effectively grounded means permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient current-carrying capacity to prevent the building up of voltages which may result in undue hazard to connected equipment or to persons.

Grounded System means a system of conductors in which at least one conductor or point (usually the middle wire, or neutral point of transformer or generator windings) is intentionally grounded, either solidly or through a current limiting device. This ground connection may be at one or more points.

Grounding Conductor. See Conductor.

Guarded means covered, shielded, enclosed, or otherwise protected, by means of suitable covers, casings, barriers, rails or screens, or by means of mats, or platforms, to remove the liability of dangerous contact or approach by persons or objects to a point of danger. Wires, which are insulated, but not otherwise protected, are not considered as guarded. (See Definition of Insulated).

Guard Zone. See Volume 1.

Handhole. See Volume 1.

Hazardous Locations. See Section 13–500.

Hoistway means any shaftway, hatchway, wellhole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Inclosed. See Enclosed.

Insulated means separated from other conducting surfaces by a dielectric substance or air space permanently offering a high resistance to the passage of current and to disruptive discharge through the substance or space.

Note: When any object is said to be insulated, it is understood to be insulated in a suitable manner for the conditions to which it is subjected. Otherwise, it is within the purpose of these rules, uninsulated. Insulating covering of conductors is one means of making the conductors insulated.

Insulating (where applied to the covering of a conductor or to clothing, guards, rods, and other safety devices) means that a device, when interposed between a person and current-carrying parts, protects the person making use of it against electric shock from the current-carrying parts with which the device is intended to be used. (The opposite of conducting.)

Isolated means that an object is not readily accessible to persons unless special means for access are used. (See definition of exposed).

Isolated Plant means a private electrical installation deriving energy from its own generator driven by a prime mover.

Isolating Switch. See switch.

Isolation by Elevation means elevated sufficiently so that persons may safely walk underneath. (See definition of exposed)

Joint Use means simultaneous use by two or more kinds of utilities.

Lateral Conductor. See Conductor.

Lateral Working Space. See Volume 1.

Lighting Outlet means an outlet intended for the direct connection of a lampholder, a lighting fixture or a pendent cord terminating in a lampholder.

Lightning Arrester as applied to Supply Circuits means a device which has the property of reducing the voltage of a surge applied to its terminals, is capable of interrupting follow current if present, and restores itself to its original operating condition.

Line Conductor. See Conductor.

Lines. See Volume 1.

Location:

Dry Location means a location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

Damp Location means a location subject to a moderate degree of moisture, such as some basements, some barns, some cold storage warehouses, and the like.

Wet Location means a location subject to saturation with water or other liquids, such as locations exposed to the weather, wash rooms in garages, and like locations. Installations underground or in concrete slabs or masonry in direct contact with the earth, shall be considered as wet locations.

Low-Energy Power Circuit means a circuit which is not a remote-control or signal circuit but which has the power supply limited in accordance with the requirements of Class 2 remote-control circuits. See Section 13–725.

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

Low-voltage Protection means the effect of a device operative on the reduction or failure of voltage to cause and maintain the interruption of power supply to the equipment protected.

Low-voltage Release means the effect of a device operative on the reduction or failure of voltage to cause the interruption of power supply to the equipment, but not preventing the reestablishment of the power supply on return of voltage.

Manhole. See Volume 1.

Manual means capable of being operated by personal intervention.

Minor Communication Lines. See Volume 1.

Motor Circuit Switch. See Switch.

Movable Equipment means electrical apparatus which is heavier than portable equipment as defined below, but which, nevertheless, is designed to be transported from place to place for use; equipment which is stationary when in use, but is designed for being transported from job to job. (See Definition of Portable Appliance).

Multi-outlet Assembly means a type of surface raceway, designed to hold conductors and plug receptacles, assembled in the field or at the factory.

New Construction means all new electrical installations and all extensions and renewals which constitute a substantial portion of the installation.

Open Wire. See Volume 1.

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

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

Panelboard means a single panel, or group of panel units designed for assembly in the form of a single panel; including busses and with or without switches and/or automatic overcurrent protective devices for the control of light, heat, or power circuits of small individual as well as aggregate capacity; designed to be placed in a cabinet or cutout box placed in or against a wall, or partition, and accessible only from the front. (See Definition of Switchboard).

Permanently Grounded. See Grounded, Effectively.

Pole Face. See Volume 1.

Portable Appliance means an appliance capable of being readily moved where established practice or the conditions of use make it necessary or convenient for it to be detached from its source of current by means of flexible cord and attachment plug. This includes apparatus which can be easily moved about or lifted and is intended to be so handled when in use.

Qualified Person means one familiar with the construction and operation of the apparatus and the hazards involved.

Raceway means any channel for holding wires, cables or bus-bars, which is designed expressly for, and used solely for, this purpose.

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

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

Readily Accessible means capable of being reached quickly, for operation, renewal or inspection, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc.

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

Reconstruction means replacement of a substantial portion of an existing installation by new equipment or construction. Does not include ordinary maintenance replacements.

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

Rural Districts. See Volume 1.

Sag. See Volume 1.

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

Service:

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

Service Cable means service conductors made up in the form of cable.

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

Service Drop means that portion of overhead service conductors between the pole and the first point of attachment to the building.

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

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

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

Service Raceway means the rigid metal conduit, electrical metallic tubing, or other raceway, that encloses service-entrance conductors.

Setting (of circuit-breaker) means the value of the current at which it is set to trip.

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

Signal Circuit means any electrical circuit which supplies energy to a device which gives a recognizable signal.

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

Shall is used to indicate requirements.

Should is used to indicate recommendations, or that which is advised but not required. In general, recommendations have the form of fine-print notes or paragraphs supplementing the preceding text.

Span Length. See Volume 1.

Special Permission means the written consent of the Industrial or Public Service Commission.

Structure Conflict. See Volume 1.

Substantial means so constructed and arranged as to be of adequate strength and durability for the service to be performed under the prevailing conditions.

Switch:

Switch means a device for opening or closing or changing the connection of a circuit. In these rules, a switch will always be understood to be manually operated unless otherwise stated.

General-Use Switch means a switch intended for use as a switch in general distribution and branch circuits. It is rated in amperes and is capable of interrupting its rated current at its rated voltage.

Isolating Switch means a switch intended for isolating an electric circuit from the source of power. It has no interrupting rating and is intended to be operated only after the circuit has been opened by some other means.

Motor-Circuit Switch means a switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower as the switch at the rated voltage.

Switchboard means 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.)

Tags mean tags or other markers of distinctive appearance, indicating that men are at work on the equipment or lines so designated.

Tension. See Volume 1.

Transformer Vault means an isolated fire-resistant enclosure, either above or below ground, in which transformers and related equipment are installed and which is not continuously attended during operation.

Urban Districts mean thickly settled areas, whether inside city limits or not.

Utilization Equipment. See Equipment.

Vapor-tight means so enclosed that vapor will not enter the enclosure.

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

Vertical Conductor. See Conductor.

Voltage:

Voltage of a circuit means the greatest effective difference of potential between any two conductors of the circuit concerned.

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

Where one circuit is directly connected to another circuit of higher voltage (as in the case of auto transformers) both are considered of the higher voltage, unless the circuit of lower voltage is effectively grounded.

When the term "volts" or "voltage" is used without qualification in Volume 1 it means the voltage between conductors if no grounded conductor capable of carrying load is present. If such a grounded conductor is present, "volts" or "voltage" means volts to ground.

Watertight means so constructed that moisture will not enter the enclosing case.

Weatherproof as applied to the protective covering on conductors means a covering made up of braids of fibrous material which are thoroughly saturated with a dense moisture-proof compound after they have been placed on the conductor or an equivalent protective covering designed to withstand weather conditions.

Weatherproof as applied to exterior installations means so constructed or protected that the weather will not interfere with successful operation.

Wire Gauges. The American Wire Gauge (A.W.G.), otherwise known as Brown & Sharpe (B.&S.), is the standard gauge for copper, aluminum, and other conductors, excepting steel, for which the steel wire gauge (Stl.W.G.), is used throughout this code.

PART 3

ELECTRICAL AND COMMUNICATION EQUIPMENT AND WIRING INCLUDING GROUNDING

Chapter 1. General

Section 13-00. Scope of Orders.

In Part 3, the National Electrical Code has generally been followed. The number of the National Electrical Code rule corresponding to any order in this part may be determined by dropping the first two digits and the hyphen. In a few cases the orders differ from the wording of the National Electrical Code rule.

Note a. Throughout this part of the code are paragraphs which state only fundamentals or objectives of safeguarding. These are followed by paragraphs setting forth the recognized methods and detail by which the purposes and intent of the fundamental may be satisfied. Accordingly, when employed, the rules stating a fundamental only will appear as the first paragraph of a section or order.

Note b. The first four chapters of Part 3 are of general application to the equipment not exempted by Order 13-0001. Chapters 5, 6, and 7 apply to installations which involve special occupancies, special equipment or other special conditions. These chapters are supplementary to, or amendatory of, the general orders, and the latter apply under such circumstances except as so amended for the particular conditions. Chapter 8 governs installations of communication systems, and is independent of the preceding chapters except as they may be specifically referred to. Chapter 9 covers construction specifications. The larger tables, examples and the diagrams are collected in Chapter 10.

Order 13-0001. Application of Orders.

A. *General.* 1. Except as otherwise specified hereafter, the following orders, Chapters 1 to 10 inclusive, which have for their purpose the practical safeguarding of persons and buildings and their contents from electrical hazards arising from the use of electricity, apply to the electric and communication conductors and equipment installed within or on public and private buildings and other premises, including yards, carnival and parking lots, and industrial substations; also the conductors that connect the installations to a supply of electricity, and other outside conductors adjacent to the premises.

2. These orders do not apply to installations in ships, aircraft, railway cars or automotive equipment.

3. These orders do not apply to installations employed by a railway, electric or communication utility in the exercise of its function as a utility where the installations are located outdoors or in quarters

used exclusively for that purpose, but they do apply to wires used in such quarters to distribute a power supply for lighting, service outlets, and other utilization equipment.

4. Chapter 8 governs the installation of communication systems. No other chapters of Part 3 apply to such installations, except as they may be specifically referred to in Chapter 8.

Note a. The provisions of this Code constitute a minimum standard. Compliance therewith and proper maintenance will result in an installation reasonably free from hazard but not necessarily efficient or convenient. This Code is to be regarded neither as a design specification nor an instruction manual for untrained persons. Good service and satisfactory results will often require larger sizes of wire, more branch circuits, and better types of equipment than the minimum which is here specified.

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

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

B. *Equipment of More than 600 Volts.* 1. All electrical equipment and conductors of more than 600 volts shall comply with the orders applying to electrical supply stations, Part 1. (See Order 1100).

2. If such equipment and conductors are installed in supply station or other quarters accessible only to qualified persons, they need not comply with the orders of Part 3, but only with the orders of Part 1.

3. If such equipment and conductors are not installed in supply stations or other quarters accessible only to qualified persons, they shall comply with the orders of Part 3 for equipment of over 600 volts (See Section 13-710) and also with the orders of Part 1. In addition, all current-carrying parts shall be either incased in effectively grounded metal cases or conduit, or otherwise suitably guarded to prevent access (or too close approach) to such current-carrying parts by any but qualified persons.

C. *Equipment Accessible to Qualified Persons Only.* Electrical equipment and conductors, if installed in supply stations or other quarters accessible only to qualified persons, may be installed in conformity with the orders applying to electrical supply stations (Part 1), in which case only wiring used to distribute a power supply for lighting, service outlets and other utilization equipment need comply with the orders of Part 3. (See Order 1100).

SECTION 13-100. DEFINITIONS

The "definitions" will be found in Order 1020, Introductory Part.

SECTION 13-110. GENERAL

Order 13-1101. Approval.

The conductors and equipment required or permitted by this Code shall be acceptable only if approved. See definitions of "Approved" in Order 1020.

Order 13-1102. Wiring Methods.

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

B. All conductors shall be guarded in an approved manner when brought closer to floor or platform than 7 feet, or when exposed to mechanical injury above that level.

Exception: Trolley conductors, grounding conductors size No. 4 or larger, lightning arrester ground conductors, pendants and portable cords are exempt from this order.

C. All conductors for light, heat or power for interior wiring systems in schools, theaters, assembly halls, hotels, hospitals, public garages, as well as apartments and office buildings of fire-resistive construction, shall be guarded by enclosure in rigid or flexible conduit, electrical metallic tubing, armored cable, surface metal raceways or other approved raceways.

Exception: (1) Wiring for lighting purposes, except lightning arrester ground conductors, in schools and assembly halls of frame construction may be of concealed knob and tube construction or non-metallic sheathed cable when protected against mechanical injury.

(2) Pendants and portable cords are exempt from this order.

Note: (1) The Wisconsin State Building Code defines assembly halls as including all buildings or parts of buildings not included under theaters where 100 or more persons assemble for entertainment, instruction, worship or dining purposes.

(2) Communication equipment, connected to communication lines and all other communication, signal and low voltage control systems, radio apparatus and similar apparatus are specifically covered in sections 13-725; 13-800 or 13-810.

D. Bus-bars and other open bare ungrounded conductors which are elevated less than eight feet above floor or platform, shall be enclosed by suitable guards.

Order 13-1103. Mandatory and Advisory Rules.

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

Order 13-1104. Special Chapters Amendatory of General Rules.

The provisions of Chapters 5, 6 and 7 of this Code are supplementary to, or amendatory of, the general provisions of Chapters 1 to 4, inclusive, and the latter apply under such circumstances except as so amended for particular conditions.

Order 13-1105. Mechanical Execution of Work.

Electrical equipment shall be installed in a neat and workmanlike manner.

Order 13-1106. Mounting of Equipment.

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

Order 13-1107. Voltages.

Throughout this Code the voltage considered shall be that at which the circuit operates, whether the current is supplied by a battery, generator, transformer or rectifier. (See Voltage. Order 1020)

Order 13-1108. Conductor Gauges.

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

Order 13-1109. Conductors.

Conductors normally used to carry current shall be of copper unless otherwise provided in this code. Where conductor sizes are given in this code, they shall apply to copper conductors. If other materials are used, the size shall be changed accordingly. See Order 13-3106.

Order 13-1110. Deteriorating Agencies.

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

Order 13-1111. Light and Power from Railway Conductors.

Circuits for lighting and power shall not be connected to any system containing trolley wires with a ground return, except in electric railway cars, car houses, power houses, or passenger and freight stations operated in connection with electric railways.

Order 13-1112. Working Space About Electrical Equipment.

Suitable working space shall be provided and maintained about all electrical equipment.

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

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

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

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

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

For higher voltages, see Section 13-710.

B. *Clear Spaces.* Working spaces adjacent to exposed live parts shall not be used as passageways.

C. *Elevation of Equipment.* The elevation of the equipment at least 8 feet above ordinarily accessible working platforms usually affords protection at least equivalent to that provided by the horizontal clearances of paragraph A and may be used in lieu thereof.

Order 13-1113. Guarding of Live Parts.

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

A. In a room or enclosure which is accessible only to qualified persons;

B. On a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons;

C. Elevated 8 feet or more above the floor;

D. So that it will be protected by a guard rail if the equipment operates at 100 volts or less.

For motors see order 13-4432.

Order 13-1114. Enclosure of Arcing Parts.

Parts of electrical equipment which in ordinary operation produce arcs, sparks, flames or molten metal, shall be enclosed unless separated and isolated from all combustible material. For hazardous locations see Section 13-500. For motors see Orders 13-4308 and 13-4310.

Order 13-1115. Interrupting Capacity.

Devices intended to break current shall have an interrupting capacity sufficient for the voltage employed and for the current which must be interrupted.

Order 13-1116. General Plans of Investigation.

Materials, devices, fittings, apparatus, and appliances designed for use under this Code shall be judged chiefly with reference to the

following considerations which also determine the classification by types, sizes, voltages, current capacities, and specific uses:

A. Suitability for installation and use in conformity with the provisions of this Code.

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

C. Electrical insulation.

D. Heating effects under normal conditions of use and also under abnormal conditions liable to arise in service.

E. Arcing effects.

Order 13-1117. Connections to Terminals.

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

Because of different characteristics of copper and aluminum the devices and fittings, such as pressure connectors, splices, solder lugs, solders, and fluxes, employed where making connections, should be suitable for the material of the conductor.

Order 13-1118. Splices.

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

Order 13-1119. Insulation Resistance.

All wiring shall be so installed that when completed the system will be free from short-circuits and grounds, and in order that a reasonable factor of safety may be provided the following table of insulation resistance is suggested as a guide where the insulation is subjected to test.

1. For circuits of No. 14 or No. 12 wire----------1,000,000 ohms

For circuits of No. 10 or larger conductor, a resistance based upon the allowable current-carrying capacity of conductors as fixed in Tables 1 and 2 of Chapter 10, of this code as follows:

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

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

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

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

Order 13-1120. Marking.

The maker's name, trademark, or other identification symbol shall be placed on all electrical equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as are prescribed elsewhere in this Code.

Chapter 2. Wiring Design and Protection

SECTION 13-200. POLARITY IDENTIFICATION OF SYSTEMS AND CIRCUITS

Order 13-2001. General.

All interior wiring systems, except as provided in Orders 13-2007, 13-2512, 13-2514, 13-2515, 13-2516, 13-2517 and 13-5083 shall have a grounded conductor which is continuously identified throughout the system, except as permitted by paragraph B of order 13-2005.

Order 13-2002. Connection to Grounded System.

No interior wiring shall be electrically connected to a supply system unless the latter contains, for any grounded conductor of the interior system, a corresponding conductor which is grounded.

Order 13-2003. Circuits Derived from Auto-Transformers.

Branch circuits as described in Section 13-210 shall not be supplied through auto-transformers (transformers in which a part of the winding is common to both primary and secondary circuits) unless the system supplied has an identified grounded conductor which is solidly connected to a similar identified grounded conductor of the system supplying the auto-transformer.

Order 13-2004. Connections to Screw-Shells.

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

Order 13-2005. Means of Identification of Conductors.

Identification for conductors shall be secured as follows:

A. Insulated conductors of No. 6 or smaller, except conductors of the weatherproof type, shall have an outer identification as specified in paragraph D of Order 13-93101.

B. Insulated conductors larger than No. 6, and weatherproof conductors of all sizes if used indoors, shall have an outer identification as specified in Paragraph D of Order 13-93101, or shall be identified by distinctive marking at terminals during process of installation.

C. Flexible cords shall be identified as provided in Order 13-94002.

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

Order 13-2006. Identified Conductor in Identified Circuits Only.

Conductors having white or natural gray covering shall not be used other than as conductors for which identification is required by Order 13-2001, except under the following conditions, and then only

if they are, in other respects, suitable for use as ungrounded conductors in the circuit:

A. Identified conductors, rendered permanently unidentified by painting or other effective means at each outlet where the conductors are visible and accessible, may be used as unidentified conductors.

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

B. Cable containing an identified conductor may be used for single-pole, three-way or four-way switch loops if the connections are so made that the unidentified conductor is the return conductor from the switch to the outlet.

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

C. A flexible cord, for connecting a portable appliance, having one conductor identified as required by Order 13-94002 may be used even though there is no grounded conductor in the circuit supplying the outlet to which it is connected.

Order 13-2007. Unidentified Circuits.

Two-wire branch circuits and multi-wire A.C. circuits may be tapped from the ungrounded conductors of circuits having identified grounded neutrals. Switching devices in such circuits shall have a pole in each ungrounded conductor, except as provided for motor controllers in Order 13-4384. Polyphase circuits need not have one conductor grounded and identified, except as required by Order 13-2514, but if one conductor is grounded it shall be identified. Other unidentified ungrounded systems or circuits may be used only by special permission.

Order 13-2008. Identification of Terminals.

All devices provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have, unless specifically excepted, a pair of connecting terminals properly marked for identification, unless the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.

A. *Panelboards and Devices.* The terminals of lighting panelboards and of devices having a normal current rating of over 30 amperes need not be marked for identification, except as required in paragraphs E and F of this order for polarized receptacles for attachment plugs and polarized attachment plug caps.

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

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

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

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

F. *Three-wire Receptacles and Caps.* Three-wire attachment plug receptacles and three-wire attachment-plug caps, one terminal of which may be used for the connection of a grounding conductor, shall have such terminal identified in a manner differing from that specified in Order 13-2009. The other terminals need not be marked for identification.

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

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

Order 13-2009. Means of Identification of Terminals.

The marking of terminals shall be done by means of a metallic plated coating substantially white in color, as nickel or zinc, or the terminals may be of material substantially white in color. The other terminals shall be of a readily distinguishable different color.

SECTION 13-210. BRANCH CIRCUITS

GENERAL

Order 13-2101. Scope.

The provisions of this section shall apply to branch circuits supplying lighting or appliance loads or combinations of such loads. If motors, or motor-operated appliances, are connected to any circuit supplying lighting or other appliance loads, the provisions of both this section and Section 13-430 shall apply. Section 13-430 shall apply if branch circuit supplies only motor loads.

Order 13-2102. Other Provisions.

The provisions applying to branch circuits referred to in the following table are exceptions to the provisions of this section or are supplementary thereto, and shall apply to branch circuits supplying the loads referred to therein:

	Section or Order
Busways	13–3647
Cranes and Hoists	13–6142
Elevators	13–6251
Infra-red Industrial Heating Equipment	13–4237
Induction and Dielectric Heat Generating Equipment	Section 13–665
Instruments	13–93843
Motors	Section 13–430
Organs	13–6506
Remote-Control, Low-Energy Power and Signal Circuits	Section 13–725
Signs and Outline Lighting	13–6006
Sound Recording and Reproduction	13–6406
Systems over 600 Volts	13–7141 to 13–7144
Systems under 50 Volts	13–7204
Theatres and Similar Occupancies	13–5241, 13–5286, 13–5292
Welders	Section 13–630

Order 13–2103. Classification.

Branch circuits recognized by this section shall be classified in accordance with the maximum permitted rating or setting of the overcurrent device, and the classification for other than individual branch circuits shall be 15, 20, 30 and 50 amperes. When conductors of larger size are used to provide for voltage drop, the rating or setting of the specified overcurrent device shall determine the circuit classification.

GENERAL PROVISIONS

Order 13–2111. Multi-Wire Branch Circuits.

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

Order 13–2112. Color Code.

If installed in raceways, as open work, or as concealed knob and tube work, the conductors of multi-wire branch circuits and two-wire branch circuits connected to the same system shall conform to the following color code. Three-wire circuits—one black, one white, one red; four-wire circuits—one black, one white, one red, one blue; five-wire circuits—one black, one white, one red, one blue, one yellow. If more than one multi-wire branch circuit is carried through a single raceway the ungrounded conductors of the additional circuit may be of colors other than those specified. All circuit conductors of the same color shall be connected to the same ungrounded feeder conductor throughout the installation.

Order 13–2113. Voltage.

Branch circuits supplying lampholders, fixtures, or receptacles of the standard 15-ampere or less rating shall not exceed 150 volts to

ground, except (1) in industrial establishments the voltage may exceed 150 volts to ground, but shall not exceed 300 volts to ground for branch circuits supplying lighting fixtures only that are equipped either with mogul-base screw-shell lampholders or with lampholders of other types approved for the application, mounted not less than 8 feet from the floor, which do not have switch control as an integral part of the fixture; (2) in railway properties as described in Order 13–1111; (3) for infra-red industrial heating appliances as described in Order 13–4237. In dwelling occupancies, the voltage between conductors supplying lampholders of the screw-shell type, receptacles, or appliances, shall not exceed 150 volts, except that the voltage between conductors supplying only, (1) permanently connected appliances, or (2) portable appliances of more than 1,380 watts, or (3) portable motor-operated appliances of ¼ horsepower or greater rating may exceed 150 volts.

Order 13–2114. Heavy-Duty Lampholders.

Heavy-duty lampholders as referred to in this section shall include Edison-base lampholders of the mogul type, and other lampholding devices required for lamps exceeding the maximum rating of the medium-base lamp as provided in Order 13–94103.

Order 13–2115. Branch Circuits Required.

Branch circuits shall be installed as follows:

A. Lighting and Appliance Circuits. For lighting, and for appliances, including motor-operated appliances, not specifically provided for in paragraph B, branch circuits shall be provided for a computed load not less than that determined by Order 13–2116.

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

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

If lighting units to be installed operate at other than 100 per cent power factor, see paragraph B of Order 13–2125 for maximum ampere load permitted on branch circuits.

For general illumination in dwelling occupancies, it is recommended that not less than one branch circuit be installed for each 500 square feet of floor area in addition to the receptacle circuit called for in paragraph B, below.

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

B. Receptacle Circuits (Dwelling Occupancies). For the small appliance load in kitchen, laundry, pantry, dining room and breakfast room of dwelling occupancies, one or more branch circuits shall be provided for all receptacle outlets (other than outlets for clocks) in these rooms and such circuits shall have no other outlets. The conductors of such circuits shall be not smaller than No. 12.

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

Order 13–2116. Calculation of Load.

The branch circuit load for lighting and appliances shall be computed in accordance with the provisions of this order. Where in normal operation the maximum load of a branch circuit will continue for long periods of time, such as store lighting and similar loads, the minimum unit loads specified in this order shall be increased by 25 per cent in order that the wiring system may have sufficient branch circuit and feeder capacity to insure safe operation.

A. General Lighting. For general illumination:

1. In Listed Occupancies. In the occupancies listed in the table in Order 13–2203, a load of not less than the unit load of Column A shall be included for each square foot of floor area.

In determining the load on the "watts per square foot" basis, the floor area shall be computed from the outside dimensions of the building, apartment or area involved, and the number of floors; not including open porches, garages in connection with dwelling occupancies, nor unfinished spaces and unused spaces in dwellings unless adaptable for future use.

All receptacle outlets of 15-ampere or less rating in single-family and multi-family dwellings and in guest rooms of hotels (except those connected to the receptacle circuits specified in paragraph B of Order 13–2115) may be considered as outlets for general illumination, and no additional load need be included for such outlets. The provisions of paragraph B of this order shall apply to all other receptacle outlets.

2. In Other Occupancies: In other occupancies, a load of not less than the unit load specified in paragraph B of this order shall be included for each outlet.

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

*Outlets supplying specific appliances and other loads.

	Amp. rating of appliance
Outlets supplying heavy-duty lampholders	5 amperes
‡Other outlets	1½ amperes

* For motors, see Orders 13–4314 and 13–4316.

‡ This provision not applicable to receptacle outlets connected to the circuits specified in paragraph B of Order 13–2115 nor to receptacle outlets provided for the connection of fixed lighting units to facilitate servicing and replacement.

C. Exceptions. The minimum load for outlets specified in paragraph B shall be modified as follows:

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

2. Show-Window Lighting. For show-window lighting a load of not less than 200 watts for each linear foot of show-window, measured horizontally along its base, may be allowed in lieu of the specified load per outlet.

3. Multi-Outlet Assemblies. Where, in other than dwellings and guest rooms of hotels, fixed multi-outlet assemblies are employed, each five feet or fraction thereof of each separate and continuous length shall be considered as one outlet of not less than 1½ ampere capacity; except in locations where a number of appliances are likely to be used simultaneously, when each one foot or fraction thereof shall be considered as an outlet of not less than 1½ amperes.

4. Telephone Exchanges. Shall be waived for manual switchboards and switching frames in telephone exchanges.

D. Existing Installations. Additions to existing installations shall conform to the following:

1. Dwelling Occupancies. New circuits or extensions to existing circuits may be determined in accordance with paragraphs A or B of this order; except that portions of existing structures not previously wired, or additions to the building structure, either of which exceeds 500 square feet in area, shall be determined in accordance with paragraph A of this order.

2. Other Than Dwelling Occupancies. When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of paragraphs A or B of this order shall apply.

SPECIFIC REQUIREMENTS

Order 13–2121. Conductors.

Circuit conductors shall conform to the following:

A. *Carrying Capacity.* Shall have a carrying capacity of not less than the rating of the branch circuit and not less than the maximum load to be served.

B. *Minimum Size.* Shall be not smaller than No. 8 for ranges of 8¾ kw or more rating, nor smaller than No. 14 for other loads.

See paragraph B of Order 13–2115.

C. *Exceptions:*

1. Range Loads. See Note 5 of Table 29, Chapter 10. Where the maximum demand of a range of 8¾ kw or more rating is computed according to Column A of Table 29, Chapter 10, the neutral conductor of a three-wire branch circuit supplying a household electric range may be smaller than the ungrounded conductors but shall have a carrying capacity at least 70 per cent of the current-carrying capacity of the ungrounded conductors and shall not be smaller than No. 10.

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

2. Taps. Taps to individual lampholders or fixtures, taps not over 18 inches long to individual outlets, or taps to infra-red lamp industrial heating appliances, may be of less capacity than the branch circuit rating; but not less than the load to be served, and not smaller than No. 12 for 50-ampere circuits and No. 14 for other circuits.

3. Fixture Wires and Cords. Fixture wires and cords may be of smaller size, but not less than the size specified in paragraph D of Order 13–2403.

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

4. Outlet Devices. Outlet devices may have less carrying capacity than the branch circuit rating, but not less than the types and ratings specified in paragraphs A and B of Order 13–2123.

Order 13–2122. Overcurrent Protection.

The rating or setting of overcurrent devices shall conform to the following:

A. *Rating.* Shall not be in excess of the carrying capacity of the circuit conductor.

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

C. *Exceptions:*

1. Taps and Fixture Wires. Taps, fixture wires and cords as permitted in paragraph C of Order 13–2121 may be considered as protected by the circuit overcurrent device.

Order 13–2123. Outlet Devices.

Outlet devices shall conform to the following:

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

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

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

Receptacles connected to circuits of more than 150 volts between conductors shall be of such design that attachment plug caps used on circuits of other voltages on the same premises cannot be inserted in them.

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

C. *Exceptions:*

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

Order 13–2124. Receptacle Outlets Required.

Receptacle outlets shall be installed as follows:

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

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

B. *Dwelling Type Occupancies.* In every kitchen, dining room, breakfast room, living room, parlor, library, den, sun room, recreation room and bedroom, one receptacle outlet shall be provided for every 20 linear feet or major fraction thereof of the total (gross) distance around the room as measured horizontally along the wall at the floor line. The receptacle outlets shall, insofar as practicable, be spaced equal distances apart. At least one receptacle outlet shall be installed for the connection of laundry appliances. This receptacle shall be of a 3-pole type designed for grounding. Receptacle outlets in floor shall not be counted as part of the required number of receptacle outlets unless located close to the wall.

See Examples 1, 2 and 4, Chapter 10.

Order 13–2125. Maximum Load.

The maximum load shall conform to the following:

A. *Motor-Operated Appliances.* The total load shall not exceed 80 per cent of the branch circuit rating if motor-operated appliances are supplied. If circuit supplies only motor-operated appliance loads, Section 13–430 is to apply.

B. *Other Loads.* The total load shall not exceed the branch circuit rating, and shall not exceed 80 per cent of the rating where in normal operation the load will continue for long periods such as store lighting and similar loads. In computing the load of lighting units which employ ballasts, transformers or auto-transformers, the load shall be based on the total of the ampere rating of such units and not on the wattage of the lamps.

C. *Exceptions:*

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

Order 13–2126. Permissible Loads.

Individual branch circuits may supply any loads. Branch circuits having two or more outlets may supply only loads as follows:

A. *15- and 20-Ampere Branch Circuits.* Lighting units and/or appliances. The rating of any one portable appliance shall not exceed 80 per cent of the branch circuit rating. The total rating of fixed appliances shall not exceed 50 per cent of the branch circuit rating if lighting units or portable appliances are also supplied.

B. *30-Ampere Branch Circuits.* Fixed lighting units in other than dwelling occupancies; or appliances in any occupancy. The rating of any one portable appliance shall not exceed 24 amperes.

C. *50-Ampere Branch Circuits.* Fixed lighting units in other than dwelling occupancies; or fixed cooking appliances; or fixed range and water heater; or infra-red lamp industrial heating appliances.

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

Order 13–2127. Table of Requirements.

The requirements for circuits having two or more outlets (other than the receptacle circuits of paragraph B of Order 13–2115) as specifically provided for above are summarized in the following table:

Branch Circuit Requirements

(Type R, RH, RW, RU, RUW, T, and TW conductors in raceway or cable)

CIRCUIT RATING	15 Amp.	20 Amp.	30 Amp.	50 Amp.
CONDUCTORS: (Min. Size)				
Circuit Wires	14	12	10	6
Taps	14	14	14	12
Fixture Wires and Cords				
OVERCURRENT PROTECTION	15 Amp.	20 Amp.	30 Amp.	50 Amp.
OUTLET DEVICES:				
Lampholders Permitted	Any Type	Any Type	Heavy Duty	Heavy Duty
Receptacle Rating	Max. 15 Amp.	15 or 20 Amp.	20 or 30 Amp.	50 Amp.
MAXIMUM LOAD	15 Amp.	20 Amp.	30 Amp.	50 Amp.
PERMISSIBLE LOAD	Order 13-2126 A	Order 13-2126 A	Order 13-2126 B	Order 13-2126 C

SECTION 13-220—FEEDERS

Order 13-2201. Feeder Size.

Feeder conductors shall be not smaller than specified in Tables 1 and 2 of Chapter 10 for the computed feeder load as determined by Order 13-2203. A 2-wire feeder supplying two or more 2-wire branch circuits, or a 3-wire feeder supplying more than two 2-wire branch circuits, or two or more 3-wire branch circuits, shall be not smaller than No. 10. If a feeder carries the total current supplied by the service-entrance conductors, such feeder, for services of No. 8 and smaller, shall be of the same size as the service-entrance conductors.

If at any time it is found that feeder conductors will be, or are, overloaded, the feeder capacity shall be increased to comply with the provisions of Tables 1 and 2 of Chapter 10 for the actual load served.

See Examples Nos. 1 to 7 of Chapter 10.

Order 13-2202. Voltage Drop.

The size of the feeder conductors should be such that voltage drop up to the final distribution point for the load as computed by order 13-2203 will not be more than 3 per cent for power loads, and not more than 1 per cent for lighting loads or combined lighting and power loads.

Order 13-2203. Calculation of Load.

The computed load of a feeder shall be not less than the sum of all branch circuit loads supplied by the feeder, as determined by Order 13-2116, subject to the following provisions:

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

See paragraph C.

Unit Loads and Feeder Demand Factors

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

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

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

Type of Occupancy	COL. A Unit Load Per Sq. Ft. (Watts)	COL. B Load to which Demand Factor Applies (Watts)	Demand Factor
Armories and Auditoriums	1	Total Wattage	100%
Banks	2	Total Wattage	100%
Barber Shops and Beauty Parlors	3	Total Wattage	100%
Churches	1	Total Wattage	100%
Clubs	2*	Total Wattage	100%
Court Rooms	2	Total Wattage	100%
Dwellings—(Other than Hotels)	3*	3,000 or less	100%
		Next 117,000	35%
		Over 120,000	25%
Garages—Commercial (storage)	½	Total Wattage	100%
Hospitals	2	50,000 or less	40%†
		Over 50,000	20%
Hotels, including apartment houses without provisions for cooking by tenants	2*	20,000 or less	50%†
		Next 80,000	40%
		Over 100,000	30%
Industrial Commercial (Loft) Buildings	2	Total Wattage	100%
Lodge Rooms	1½	Total Wattage	100%
Office Buildings	2	20,000 or less	100%
		Over 20,000	70%
Restaurants	2	Total Wattage	100%
Schools	3	15,000 or less	100%
		Over 15,000	50%
Stores	3	Total Wattage	100%
Warehouses Storage	¼	12,500 or less	100%
		Over 12,500	50%
In any of above occupancies except single-family dwellings and individual apartments of multi-family dwellings:			
Assembly Halls and Auditoriums	1	Total Wattage as specified for the specific occupancy	
Halls, Corridors, Closets	½		
Storage spaces	¼		

*See paragraph C of this order.

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

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

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

1. Dwelling Occupancies. In single-family dwellings, in individual apartments of multi-family dwellings having provisions for

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

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

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

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

See example No. 7, Chapter 10.

E. *Fixed Appliances (Other than Ranges).* Where four or more fixed appliances, in addition to an electric range or ranges, are connected to the same feeder in a single or multi-family dwelling, a demand factor of 75 per cent may be applied to the fixed appliance load, not including the electric ranges.

F. *Motors.* For motors, a load computed according to the provisions of Orders 13–4314, 13–4315 and 13–4316 shall be included.

G. *Neutral Feeder Load.* The neutral feeder load shall be the maximum unbalance of the load determined by Order 13–2203. The maximum unbalanced load shall be the maximum connected load between the neutral and any one ungrounded conductor; except that the load thus obtained shall be multiplied by 140 per cent for 5-wire, 2-phase systems. For a feeder supplying household electric ranges, the maximum unbalanced load shall be considered as 70 per cent of the load on the ungrounded conductors, as determined in accordance with Column A of Table 29, Chapter 10. For 3-wire, D.C. or single-phase A.C., 4-wire 3-phase and 5-wire 2-phase systems, a further demand-factor of 70 per cent may be applied to that portion of the unbalanced load in excess of 200 amperes.

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

Order 13–2204. Common Neutral Feeder.

A common neutral feeder may be employed for two or three sets of 3-wire feeders, or two sets of 4-wire or 5-wire feeders. When in metal enclosures, all conductors of feeder circuits employing a common neutral feeder shall be contained within the same enclosure as provided in Order 13–3018.

Order 13–2205. Diagram of Feeders.

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

SECTION 13–230. SERVICES

GENERAL REQUIREMENTS

Order 13–2301. One Set of Service Conductors Only.

In general, a building shall be supplied through only one set of service conductors, except:

A. Where more than one service drop is permitted by Order 13–2321.

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

C. In a single occupancy, where a set of service conductors is already installed for one class of use, one additional set may be installed for a different class of use. (See 13–2351B and 13–2371A4)

Order 13–2302. Service from One Building Through Another.

No overhead service, no underground service, and no service from an isolated plant shall supply one building through another, unless such buildings are under single occupancy or management. Conductors in conduit or duct placed under at least two inches of concrete beneath a building, or buried in two inches of brick masonry or in concrete within a wall, shall be considered outside the building.

Order 13–2303. Insulation of Service Conductors.

Service conductors extending from the service entrance to the first pole shall have an insulating covering which will normally withstand exposure to atmospheric and other conditions of use and which shall prevent any detrimental leakage of current to adjacent conductors, objects, or the ground.

A. *Uninsulated Neutral.* In the case of service conductors that have a nominal voltage to ground of not more than 208 volts, a grounded neutral service conductor without an insulating covering may be installed.

B. *Underground.* Except as provided in paragraph A, underground service conductors up to the point of attachment to service equipment shall be covered with rubber, cambric, thermoplastic, paper or other approved insulating material. Service conductors installed underground, or in concrete slabs or masonry in direct contact with earth, shall be lead-covered or of other types specially approved for the purpose.

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

D. *On Exterior of or Entering Buildings.* Except as provided in paragraph A, service conductors extending along the exterior of or entering buildings shall be rubber-covered or thermoplastic-covered if in raceways, or in service cables. Open individual conductors which enter the building shall be rubber-covered or thermoplastic-covered; but where on the exterior of the building only may be weatherproof (type WP).

Order 13–2304. Size of Service Conductors.

Service conductors shall have adequate current-carrying capacity to safely conduct the current for the loads supplied without a temperature rise detrimental to the insulating covering of the conductors, and shall have adequate mechanical strength.

A. *Service Entrance Conductors.* Service entrance conductors, including underground services, shall have a current carrying capacity sufficient to carry the load as determined by Order 13–2203, and in accordance with Tables 1 and 2 of Chapter 10. Service entrance conductors supplying installations of three or more branch circuits shall consist of at least two No. 6 insulated conductors and one No. 8 bare conductor. Installations having only one or two branch circuits may be served by two No. 8 conductors. The neutral of the service entrance conductors shall have a current carrying capacity in conformity with Order 13–2203, and shall be the same size as the ungrounded conductor when the ungrounded conductors are No. 8.

B. *Service Drops.* Conductors in service drops shall be not smaller than No. 10 if of soft copper, or No. 12 if of medium or hard drawn copper.

Order 13–2305. Service Entrance Conductors without Splice.

Service entrance conductors shall be without splice except as follows:

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

B. Taps to main service conductors are permitted as provided in sub-paragraph B of Order 13–2301, or to individual sets of service equipment as provided in sub-paragraph A of Order 13–2351.

C. A connection is permitted, if properly enclosed, where an underground service conductor enters a building and is to be extended to the service equipment or meter in another form of approved service raceway or service cable.

D. A connection is permitted where service conductors are extended from a service drop to an outside meter location and returned to connect to the service entrance conductors of an existing installation.

E. For extending existing services, special permission to make splices in fittings of the service run and to extend existing wire size may be granted.

Order 13–2306. Conductors in Service Raceway.

Conductors other than service conductors, grounding conductors, or control conductors from time switches having overcurrent protection, shall not be installed in the service raceway.

Water heater leads are to be considered as service entrance conductors.

Note: Where a meter is located on a pole the wires to and from the meter may be installed in the same raceway if service entrance equipment is provided at each building supplied from this pole.

UNDERGROUND SERVICES

Order 13–2311. Mechanical Protection.

Underground service conductors shall be protected against mechanical injury by being installed in duct, conduit, in the form of a cable approved for the purpose or by other approved means.

Order 13–2312. Protection on Poles.

If underground service conductors are carried up a pole the mechanical protection shall be installed to a point at least 8 feet above the ground.

Order 13–2313. Protection Where Entering Building.

Where underground service conductors enter a building, they shall have mechanical protection in the form of rigid or flexible conduit, electrical metallic tubing, auxiliary gutters, the metal tape of an approved service cable, or other approved means. The mechanical protection shall extend to the enclosure for the service equipment unless the service switch is installed on a switchboard, in which case a bushing shall be provided which, except where lead covered conductors are used, shall be of the insulating type.

Order 13–2314. Sealing End of Raceway.

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

SERVICE DROP CONDUCTORS

Order 13–2321. Number of Drops.

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

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

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

C. *Capacity Requirements.* If capacity requirements make multiple services desirable.

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

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

F. Additional drops may be supplied if they are necessary because of voltage regulation, consumer classification or regulatory orders.

Note: On a farm or any place that must depend partially or wholly upon a local motor driven pump for fire protection, it is advisable to connect that motor in such a way that the opening of other than its own circuit protection will not interrupt service to the pump.

Order 13–2322. Clearance of Service Drop.

Service drops shall not be readily accessible and shall conform to the following:

A. *Clearance Over Roof.* Conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass, except where the voltage between conductors does not exceed 300 and the roof cannot be readily walked upon, the clearance may be not less than 3 feet.

B. *Clearance from Ground.* Conductors shall have a clearance of not less than 10 feet from the ground or from any platform or projection from which they might be reached.

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

Order 13–2323. Supports Independent of Building.

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

Order 13–2324. Point of Attachment to Building.

In general, the point of attachment of a service drop to a building shall be not less than 10 feet above ground and shall be at a height to permit a minimum clearance for service drop conductors of 10 feet above sidewalks, 18 feet above alleys, roads and streets, 15 feet above farm driveways and 12 feet above drives to residence garages. The attachment should not be more than 30 feet above ground unless a greater height is necessary for proper clearance.

Order 13–2325. Means of Attachment.

Multiple conductor cables used for service drops shall be attached to buildings by fittings approved for the purpose.

SERVICE CONDUCTORS ON OR IN BUILDINGS

Order 13–2331. Wiring Methods.

Service conductors extending along the exterior, or entering buildings, may be installed as separate conductors, in cables approved for the purpose, or enclosed in rigid conduit, or, for circuits not exceeding 600 volts, in electrical metallic tubing or as busways.

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

Order 13–2332. Mechanical Protection.

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

Order 13–2333. Individual Conductors Exposed to Weather.

Individual open conductors, if exposed to weather, shall be supported on insulators, racks, brackets, or other means, placed at intervals not exceeding 9 feet and separating the conductors at least 6 inches from each other and 2 inches from the surface wired over; or at intervals not exceeding 15 feet if they maintain the conductors at least 12 inches apart. For 300 volts or less, conductors may have a separation of not less than 3 inches if supports are placed at intervals not exceeding 4½ feet and conductors are not less than 2 inches from the surface wired over. Weather-proof conductors (type WP) on exterior of buildings shall have a clearance from the ground of not less than 8 feet, and a clearance from windows, doors, porches, etc., of not less than 3 feet.

Order 13–2334. Individual Conductors Not Exposed to Weather.

Individual open conductors not exposed to the weather may be supported on glass or porcelain knobs placed at intervals not exceeding 4½ feet and maintaining the conductors at least one inch from the surface wired over and a separation of at least 2½ inches between conductors.

Order 13–2335. Individual Wires Entering Buildings.

Individual conductors entering buildings shall pass inward and upward through slanting non-combustible, non-absorptive insulating tubes, or shall enter through roof bushings, and shall conform to the provisions of Section 13–324. Drip loops shall be formed on the conductors before entering tubes.

Order 13–2336. Service Cables.

Service cables of a type not approved for mounting in contact with the wall shall have insulating supports at intervals not exceeding 15

feet, and maintaining a distance of at least 2 inches from the surface wired over. Service cables mounted in contact with the building shall be supported at intervals not exceeding 4½ feet.

Order 13-2337. Service Head.

Service raceway shall be equipped with a raintight service head. Service cable, unless continuous from pole to service equipment or meter, shall be equipped with an approved raintight service head, or be formed in a gooseneck, taped and painted and held securely in place by its connection to service-drop conductors below the gooseneck or by a fitting approved for the purpose. Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall not be connected to the service-drop conductors at a point above the level of the service head or the termination of service-entrance cable sheaths. If service heads are used, conductors of opposite polarity shall be brought out through separately bushed holes.

Order 13-2338 Enclosing Raceways Made Raintight.

If rigid metal raceways are installed where exposed to weather the raceways shall be made raintight and arranged to drain.

Order 13-2339. Terminating Raceway at Service Equipment.

If conduit, electrical metallic tubing, or service cable is used for service conductors, the inner end shall enter a terminal box or cabinet, or be made up directly to an equivalent fitting, enclosing all live metal parts, except that if the service disconnecting means is mounted on a switchboard having exposed busbars on the back, the raceway may be equipped with a bushing which shall be of the insulating type unless lead-covered conductors are used.

DISCONNECTING MEANS

Order 13-2351. General.

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

A. *Switch and Circuit-Breaker.* The disconnecting means shall be manually operable. It may consist of not more than six switches or six circuit-breakers in a common enclosure, or in a group of separate enclosures, located at a readily accessible point nearest to the entrance of the conductors, either inside or outside the building wall. The disconnecting means shall be of a type approved for service equipment and for prevailing conditions.

For service operating at not to exceed 250 volts and capacities up to and including 100 amperes, the service switch and service fuses, when not a part of a switchboard, shall be of the accessible fuse or deadfront type in which the fuses are dead when accessible and no live parts are exposed to accidental contact.

Exception. Where the meter is not of the socket type or where current transformers or large self-contained meters are used, the main disconnecting means may consist of not more than six switches or six manually-operable circuit-breakers, provided an approved disconnecting means is installed ahead of the meter or the metering current transformers. If such disconnecting means is incapable of being operated under full load, the service on which it is installed must be sealed or otherwise rendered inaccessible to other than qualified persons.

B. *Multiple-Occupancy.* In a multiple-occupancy building, each occupant shall have access to his disconnecting means. A multiple-occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the disconnecting means consisting of not more than six switches or six circuit-breakers. Multiple-occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy in accordance with 13-2301-B and each such service may have not more than six switches or circuit-breakers.

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

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

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

Order 13-2352. Connections Ahead of Disconnecting Means.

Service fuses, meters, high-impedance shunt circuits (such as potential coils of meters, etc.), supply conductors for time switches, surge protective capacitors, instrument transformers, lightning arresters and circuits for emergency lighting and for fire alarms as provided in Order 13-2375, may be connected on the supply side of the disconnecting means. Taps from service conductors to supply time switches, circuits for emergency lighting, etc., shall be installed in accordance with Order 13-2331 and disconnecting means shall be installed as required in Order 13-2351.

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

Order 13–2353. Simultaneous Opening.

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

Order 13–2354. Types Permitted.

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

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

Order 13–2355. Indicating.

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

Order 13–2356. Externally Operable.

An enclosed service switch or circuit-breaker shall be externally operable. See definition Order 1020.

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

Order 13–2357. Rating of Service Switch.

A service switch shall have a rating not less than the load to be carried determined in accordance with Order 13–2203. The service disconnecting means shall have a rating of not less than 60 amperes if a switch is used, and not less than 50 amperes if a circuit-breaker is used; however for installations consisting of not more than two 2-wire branch circuits a switch or circuit-breaker of 30-ampere minimum rating may be used.

Order 13–2358. Connection to Terminals.

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

Order 13–2359. Hazardous Locations.

Service equipment installed in hazardous locations shall comply with the requirements of Section 13–500.

Order 13–2360. Service Equipment Grouped.

If supplied at the same side of the building by more than one overhead service drop or more than one set of underground service conductors, the service equipments, except for services as permitted in Orders 13–2301B, C and 13–2321, shall be grouped and each set of equipment marked to identify it.

OVERCURRENT PROTECTION

Order 13–2371. Where Required.

Each ungrounded service entrance conductor shall have overcurrent protection.

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

1. For motor-starting currents, ratings in conformity with Orders 13–4342, 13–4362, or 13–4363 may be used.

2. Circuit-breakers may have a setting in conformity with Orders 13–2403 B & C.

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

4. In a multiple occupancy building each occupant shall have access to his over-current protective devices. A multiple occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the overcurrent protection consisting of not more than six circuit-breakers or six sets of fuses. Multiple occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy in accordance with 13–2301B and each such service may have not more than six circuit-breakers or six sets of fuses.

A set of fuses is all the fuses required to protect all the ungrounded conductors of a circuit.

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

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

Order 13–2372. Location.

The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto, unless located at the outer end of the service raceway.

Order 13–2373. Location of Branch-Circuit Overcurrent Devices.

If the service overcurrent devices are locked or sealed, or otherwise not readily accessible, branch-circuit overcurrent devices shall be installed on the load side, shall be mounted in an accessible location and shall be of lower rating than the service overcurrent device.

Order 13-2374. Protection of Special Circuits.

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

Order 13-2375. Relative Location of Overcurrent Device and Other Service Equipment.

The overcurrent device shall protect all circuits and devices except as follows:

A. The service switch may be placed on the supply side.

B. Meters, etc., as permitted in Order 13-2352, that may be connected and installed on the supply side of the disconnecting means for the service conductors. Taps from service conductors to supply time switches, etc., that are connected and installed on the supply side of the service disconnecting and overcurrent protective means, as permitted in Order 13-2352, if separately provided with over-current protection.

C. Circuits for emergency lighting may be connected on the supply side of the service overcurrent device if separately provided with overcurrent protection.

D. Circuits used only for the operation of fire alarm or other protective signaling systems may be connected on the supply side of the service overcurrent device if separately provided with overcurrent protection.

E. The meter may be placed on the supply side of the overcurrent device for alternating current supply not in excess of 300 volts between conductors, and provided the conductors between meter and service equipment are installed by any of the methods specified in Order 13-2331 for service conductors.

GROUNDING AND GUARDING

Order 13-2381. Enclosure.

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

This includes meter sockets.

Order 13-2382. Grounding.

Service equipment shall be grounded as follows:

A. Equipment. The meter and enclosure for service equipment shall be grounded in the manner specified in Section 13-250, unless (1) the voltage does not exceed 150 volts to ground and such enclosures are (2) isolated from conducting surfaces, and (3) unexposed to contact by persons or materials that may also be in contact with other conducting surfaces. The enclosure for metering equipment, installed on the supply side of the service equipment, may be grounded to the neutral conductor when the provisions of paragraph A of Order 13-2304 are complied with.

B. Raceways. Service raceways, and the metal sheath of service cables, shall be grounded. Conduit and metal pipe from underground supply shall be considered sufficiently grounded if containing lead-sheathed cable bonded to a continuous underground lead-sheathed cable system.

C. Flexible Conduit. If a service run of rigid metal raceway is interrupted by flexible metal conduit, the sections of rigid metal raceway thus interrupted shall be bonded together by a copper conductor not smaller than No. 8, using clamps or other approved means. The conductor and bonding devices shall be protected from mechanical injury. If the flexible conduit runs to the service cabinet, similar bonding shall be installed between the cabinet and the rigid raceway.

SERVICES EXCEEDING 600 VOLTS

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

1. Where step-down transformers are located outdoors.
2. Where step-down transformers are located in a separate building from the one served.
3. Where step-down transformers are located in the building served in a transformer vault conforming to the requirements of Orders 13-4541 to 13-4548, and under the sole control of the supply company.

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

Order 13-2386. General.

Service conductors and equipment used on circuits exceeding 600 volts between conductors shall comply with Orders 13-2301 to 13-2325 inclusive, Orders 13-2335, 13-2381 and 13-2382, and also the following Orders 13-2387 to 13-2392 inclusive.

Order 13-2387. Wiring Methods.

In locations accessible to other than qualified persons service entrance conductors of more than 600 volts shall be installed in rigid conduit, or as multiple conductor cable approved for the purpose. If the voltage exceeds 15,000 volts between conductors they shall enter a transformer vault conforming to the requirements of Orders 13-4541 to 13-4548. Conductors in conduit or duct and enclosed by concrete or brick not less than 2 inches thick shall be considered outside of the building. Unless conductors specifically approved for the purpose are used, raceways embedded in masonry, or exposed to the weather, or in wet locations shall be arranged to drain.

A. *Open Work.* If open work is employed where not accessible to other than qualified persons, the service conductors shall be rigidly supported on glass, porcelain or other insulators approved for the purpose, which will keep them at least 8 inches apart, except at terminals of equipment. They shall be not less than 2 inches from the surfaces wired over and for voltages exceeding 2500 not less than 3 inches.

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

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

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

E. *Guarding.* Open wires shall be guarded where accessible to unqualified persons.

Order 13–2388. Disconnecting Means.

The circuit-breaker or the alternatives for it specified in Order 13–2389 will constitute the disconnecting means required by Order 13–2351.

Order 13–2389. Overcurrent Protection.

Overcurrent devices shall be provided in accordance with the following:

A. *In Vault or Consisting of Metal-Enclosed Switchgear.* If the service equipment is installed in a transformer vault meeting the provisions of Orders 13–4541 to 13–4548, or consists of metal-enclosed switchgear, the requirements for overcurrent protection and disconnecting means may be fulfilled by the following:

1. On circuits of 15,000 volts or less, oil-filled or other fuses of suitable rating and type, which conform to Order 13–7103, may be used without switch or circuit-breaker provided they may be operated as a disconnecting means.

2. If the voltage is 25,000 or less, a non-automatic switch capable of interrupting the rated circuit load and suitable fuses may be used.

3. Automatic-trip circuit-breakers may also be used under the limitations outlined in paragraphs 1 and 2. If these limitations are exceeded, an automatic-trip circuit-breaker shall be installed in compliance with the requirments of paragraph B.

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

5. Metal-enclosed switchgear referred to in this section shall consist of switchgear having a substantial steel structure and a steel enclosure of thickness not less than ⅛ inch, over the sides and top. The enclosure shall be furnished as an integral part of the equipment. If installed over a wood floor, suitable protection thereto shall be provided.

B. *Not in Vault or Metal Enclosure.* If the service equipment is not in a vault or metal enclosure, the over-current device shall consist of an automatic trip circuit-breaker of suitable current-carrying and interrupting capacity with an overcurrent unit in each ungrounded conductor and so arranged that the operation of any one device will open all ungrounded conductors. If the voltage of the circuit exceeds 5000, the requirement of Order 13–7135 shall apply. A circuit-breaker used as service equipment shall be located as near as possible to where the service conductors enter the building, or else on a pole outside the building.

C. *Fuses.* Fuses used as permitted in paragraph A shall have an interrupting rating at least equal to the maximum short-circuit current possible in the circuit.

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

Order 13–2390. Isolating Switches.

Isolating switches shall be provided as follows:

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

B. When the fuses used with non-automatic oil switches in accordance with 13–2389–A are of a type that may be operated as a disconnect switch, they may serve as the isolating switch if they completely disconnect the oil switch and all service equipment from the source of supply.

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

Order 13–2391. Lightning Arrester.

A lightning arrester complying with the requirements of Section 13–280 shall be placed on each ungrounded overhead service conductor on the supply side of the service equipment, if called for by the authority enforcing this code.

Order 13–2392. Equipment in Secondaries.

If the primary service equipment supplies one or more transformers whose secondary windings feed a single set of mains, and the primary circuit-breaker is manually operable from a point outside the transformer vault or accessible to qualified persons only, the disconnecting means and overcurrent protection may be omitted from the secondary circuit, provided the setting of the primary circuit-breaker is such as to protect the secondary circuit. If not manually operable from outside the vault, means shall be provided to trip the breaker from outside the vault. In all other cases the secondary circuit shall be provided with a disconnecting means and overcurrent protection as required by various paragraphs of this section.

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

SECTION 13–240 OVERCURRENT PROTECTION

INSTALLATION

Order 13–2401. General Requirement.

Overcurrent protection for conductors is provided for the purpose of opening the electric circuit if the current reaches a value which will cause an excessive or dangerous temperature in the conductor or conductor insulation. A grounded conductor is considered to be protected from overcurrent if a protective device of a suitable rating or setting is provided in each ungrounded conductor of the same circuit.

Order 13–2402. Overcurrent Protection of Equipment.

Equipment shall be protected against overcurrent as specified in the references in the following table:

Branch Circuits	Section 13–210
Capacitors	Orders 13–4607B and 13–4608
Cranes and Hoists	Orders 13–6141 and 13–6142
Generators	Order 13–4454
Motors	Section 13–430
Over 600 Volts	Orders 13–7141, 13–7142 and 13–7143
Panelboards	Order 13–3882
Services	Orders 13–2371 to 13–2375
Remote-Control, Low Energy and Signal Circuits	Section 13–725
Signs and Outline Lighting	Order 13–6006
Sound Equipment	Order 13–6406
Transformers	Section 13–450
Induction and Dielectric Heat Generating Equipment	Order 13–6654

Order 13–2403. Overcurrent Protection of Conductors.

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

A. *Fuses.* If the allowable current-carrying capacity of a conductor does not correspond to the rating of a standard-size fuse, the next larger size or rating of fuse may be used but in no case shall the size or rating of the fuse exceed 150 per cent of the allowable current-carrying capacity of the conductor. Plug fuses and fuseholders shall not be used in circuits exceeding 125 volts between conductors, except circuits of a system having a grounded neutral and no conductor at more than 150 volts to ground. Plug fuses installed in residential occupancies should be of the time-delay type. The screw shell of plug type fuseholders shall be connected to the load side of the circuit.

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

C. *Adjustable-Trip Circuit-Breakers.* Adjustable-trip circuit-breakers of the thermal trip, magnetic time-delay trip or instantaneous-trip types shall be set to operate at not more than 150 per cent of the allowable current-carrying capacity of the conductor.

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

D. *Fixture Wires and Cords.* Fixture wire or flexible cord, sizes No. 16 or No. 18, and tinsel cord shall be considered as protected by 20-ampere overcurrent devices, except as provided in Order 13–6251. Flexible cords approved for use with specific appliances, shall be considered as protected by the overcurrent devices of the branch circuits of Section 13–210 when conforming to the following: 20-ampere circuits, No. 18 and larger; 30-ampere circuits, 10 amperes or over capacity. Fixture wires of the sizes permitted for taps in paragraph C–2 of Order 13–2121 shall be considered as protected by the overcurrent protection of the 20-ampere, 30-ampere and 50-ampere branch circuits of Section 13–210.

E. *Motor Circuits.* The conductors supplying motors and motor-operated appliances shall be considered as protected by the overcurrent protective devices specified in Orders 13–4322, 13–4324, and 13–4342.

F. *Branch Circuits.* Taps to individual outlets and circuit conductors supplying a single household electric range shall be considered as protected by the branch circuit overcurrent devices when in accordance with the requirements of Orders 13–2121 and 13–2122.

G. *Remote Control.* Except as provided in Section 13–725, the conductors of the control circuits of remote-control-switches shall be

considered as protected from overcurrent by overcurrent devices that are not of the so-called time-lag type and are rated or set at not more than 500 per cent of the carrying capacity of the remote-control conductors, as specified in Tables 1 and 2 of Chapter 10.

H. *Taps.* A conductor tapped from a feeder shall be considered as properly protected from overcurrent if installed in accordance with Orders 13–2434, 13–3647, and 13–4348.

Order 13–2404. Thermal Devices.

Thermal cutouts, thermal relays and other devices not designed to open short-circuits, shall not be used for protection of conductors against overcurrent due to short-circuits or grounds but may be used to protect motor branch circuit conductors from overload if protected in accordance with Order 13–4330.

Order 13–2405. Ungrounded Conductors.

An overcurrent device (fuse or overcurrent trip unit of a circuit-breaker) shall be placed in each ungrounded conductor. Circuit-breakers shall open all ungrounded conductors of the circuit. The number and position of the overcurrent units such as trip coils or relays shall be as given in Table 28, Chapter 10. Individual single-pole circuit-breakers may be used for the protection of each conductor of ungrounded 2-wire circuits, each ungrounded conductor of 3-wire direct-current or single-phase circuits, or for each ungrounded conductor of lighting or appliance branch circuits connected to 4-wire three-phase systems, or 5-wire 2-phase systems, provided such lighting or appliance circuits include a grounded conductor.

Order 13–2406. Services.

For services the number of overcurrent units shall be as specified in Order 13–2371.

Order 13–2407. Motors.

For motor-running protection the number of overcurrent units shall be as specified in Orders 13–4326, 13–4327 and 13–4328.

Order 13–2408. Feeders at Supply Stations.

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

Order 13–2409. Grounded Conductor.

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

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

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

C. For motor-running protection as provided in Orders 13–4326 and 13–4327.

Order 13–2410. Change in Size of Grounded Conductor.

Where a change occurs in the size of the ungrounded conductor, a similar change may be made in the size of the grounded conductor.

Order 13–2411. Fuses in Multiple.

For the protection of conductors, except the conductors of motor branch circuits, having allowable carrying capacities exceeding the rated capacity of the largest approved cartridge type fuse, cartridge fuses arranged in multiple may be used, provided as few fuses as possible are used and the fuses are of the same type, characteristics, and rating, and provided the fuseholder terminals are mounted on a single continuous pair of bus bars, or have an equivalent arrangement that will eliminate any potential difference between the terminals of the fuses.

LOCATION

Order 13–2434. Location in Circuit.

Overcurrent devices shall be located at the point where the conductor to be protected receives its supply, except as follows:

A. Service Conductors. An overcurrent protective device for a service conductor may be located as specified in Order 13–2372.

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

C. Taps Not Over 5 Feet Long. If (1) the smaller conductors have a current-carrying capacity of not less than the sum of the allowable current-carrying capacities for the conductors of the one or more circuits or loads supplied, (2) the tap is not over 5 feet long and does not extend beyond the switchboard, panelboard, or control devices which it supplies, and (3) except at the point of connection to open wires on insulators, is enclosed in conduit, electrical metallic tubing, or in metal gutters when not a part of the switchboard or panelboard.

D. Taps Not Over 25 Feet Long. If the smaller conductors have a current-carrying capacity at least one-third that of the conductor from which they are supplied, and provided the tap is suitably protected from mechanical injury, is not over 25 feet long, (where feeders are at a greater elevation, this distance may be increased to 50 feet) and terminate in a single circuit-breaker or set of fuses which will

limit the load on the tap to that allowed by Tables 1 and 2, Chapter 10. Beyond this point the conductors may supply any number of circuit-breakers or sets of fuses.

Order 13–2435. Location in Premises.

Overcurrent devices shall be located where they will be:

A. Readily accessible, except as provided in Order 13–2372 for service equipment and Order 13–3650 for busways.

B. Not exposed to mechanical injury.

C. Not in the vicinity of easily ignitible material.

ENCLOSURES

Order 13–2436. General.

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

Order 13–2437. Damp or Wet Locations.

Enclosures for overcurrent devices in damp or wet locations shall be of a type approved for such locations and shall be mounted so there is at least one-half inch air space between the enclosure and the supporting surface.

Order 13–2438. Vertical Position.

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

Order 13–2439. Rosettes.

Fuses shall not be mounted in rosettes.

Order 13–2440. Disconnection of Fuses and Thermal Cutouts Before Handling.

Disconnecting means shall be provided on the supply side of all fuses or thermal cutouts in circuits of more than 150 volts to ground and cartridge fuses in circuits of any voltage, if accessible to other than qualified persons, so that each individual circuit containing fuses or thermal cutouts can be independently disconnected from the source of electrical energy, except as provided in Order 13–2352 and except that a single disconnecting means may be used to control a group of circuits each protected by fuses or thermal cutouts under the conditions described in Order 13–4410.

Order 13–2441. Arcing or Suddenly-Moving Parts.

Arcing or suddenly-moving parts shall comply with the following:

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

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

CONSTRUCTION OF OVERCURRENT DEVICES

Order 13–2451. Plug Fuses of the Edison-Base Type.

Plug fuses of the Edison-base type shall conform to the following:

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

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

Order 13–2452. Holders for Plug Fuses.

Holders for plug fuses of 30 amperes or less shall not be installed unless they comply with Order 13–2453 or are made to comply with Order 13–2453 by the insertion of an adapter.

Order 13–2453. Plug Fuses and Fuseholders of Type S.

Where Type S plug fuses are to be used as the overcurrent device required by this code, the fuses and fuseholders shall conform to the following requirements:

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

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

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

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

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

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

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

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

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

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

Order 13-2461. Cartridge Fuses and Fuseholders.

Cartridge fuses and fuseholders shall conform to the following:

A. *Classification.* Cartridge fuses and fuseholders shall be classified as regards current and voltage as follows:

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

B. *Non-Interchangeable.* Cartridge fuses and fuseholders shall be so designed that it will be impossible to put a fuse of any given class into a fuseholder which is designed for a current lower, or voltage higher, than that of the class to which it belongs.

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

Order 13-2471. Link Fuses and Fuseholders.

Link fuses shall be mounted on approved fuseholders.

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

Order 13-2481. Circuit-Breakers.

Circuit-breakers shall conform to the following:

A. *Method of Operation.* In general, circuit-breakers shall be capable of being closed and opened by hand without employing any other source of power, although normal operation may be by other power such as electrical, pneumatic, and the like. Large circuit-breakers which are to be closed and opened by electrical, pneumatic, or other power shall be capable of being closed by hand for maintenance purposes and shall also be capable of being tripped by hand under load without the use of power.

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

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

D. *Non-Tamperable.* An air circuit-breaker, used for the branch circuits described in Section 13-210, shall be of such design that any alteration of its trip point (calibration), or in the time required for its operation, will be difficult.

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

SECTION 13-250. GROUNDING

Order 13-2501. Scope.

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

SYSTEMS AND CIRCUITS

Order 13-2511. Circuits.

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

For instrument transformer grounding, see Order 13-2621.

Order 13-2512. Two-Wire Direct-Current Systems.

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

It is recommended that 2-wire direct-current systems operating at more than 300 volts between conductors be grounded if a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. It is recommended that 2-wire direct-current systems be not grounded if the voltage to ground of either conductor would exceed 300 volts after grounding. See Order 13-2522.

Order 13-2513. Three-Wire Direct-Current Systems.

The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded. See Order 13-2522.

Order 13-2514. Alternating-Current Systems.

Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, shall be grounded if they can be so grounded that the maximum voltage to ground does not exceed 300 volts.

Higher voltage circuits may be grounded.

Order 13-2515. Furnace Circuits.

Electric furnace circuits need not be grounded.

Order 13-2516. Electric Crane Circuits.

Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See Order 13-5083.

Order 13–2517. Circuits of Less Than 50 Volts.

Circuits of less than 50 volts need not be grounded, except as follows:

A. If supplied by transformers from systems of more than 150 volts to ground, except as provided in paragraph C of Order 13–2545;

B. If supplied by transformers from ungrounded systems;

C. If run overhead outside of buildings.

LOCATION OF GROUNDING CONNECTIONS

Order 13–2521. Current Over Grounding Conductors.

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

Order 13–2522. Grounding Connection for Direct-Current Systems.

Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services nor elsewhere on interior wiring.

Order 13–2523. Grounding Connection for Alternating-Current Systems.

Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each individual service, except as provided for in Order 13–2521. The connection shall be made on the supply side of the service disconnecting means. Each secondary distribution system which is grounded shall have at least one additional connection to a grounding electrode at the transformer or elsewhere. No connection to a grounding electrode shall be made to the grounded circuit conductor on the load side of the service disconnecting means, except as provided for in Order 13–2524.

Order 13–2524. Two or More Buildings Served by a Single Service.

If more than one building is served by the same service, the grounded circuit conductor of the wiring system of any building utilizing one branch circuit supplied from such service may be connected to a grounding electrode at such building, and in the case of any building utilizing two or more branch circuits supplied from such service, and in the case of a building housing live stock, shall be so connected.

When a metal raceway system is used in any such building supplied from a single service and this metal raceway or any connected non-current carrying metal part is accessible from any grounded surface, the metal raceway system and the neutral conductor shall be bonded together and connected to an approved ground electrode at the entrance to the building.

Order 13–2525. Conductor to be Grounded.

For alternating-current interior wiring systems the conductor to be grounded shall be as follows:

A. Single-phase, 2-wire: the identified conductor;

B. Single-phase, 3-wire: the identified neutral conductor;

C. Multi-phase systems having one wire common to all phases: the identified common conductor;

D. Multi-phase systems having one phase grounded: the identified conductor;

E. Multi-phase systems in which one phase is used as in (B): the identified neutral conductor. One phase only can be grounded.

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

Order 13–2526. Isolated Systems.

For an interior wiring system or circuit which is required to be grounded and which is not connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard, on the supply side of the first switch controlling the system.

CONDUCTOR ENCLOSURES

Order 13–2531. Exposed Metal.

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

Order 13–2532. Service Conductor Enclosures.

Service raceways, service cable sheaths or armoring, if of metal, shall be grounded.

Order 13–2533. Other Conductor Enclosures.

Metal enclosures for conductors shall be grounded, except in runs of less than 25 feet which are free from probable contact with ground or grounded metal and which, if within reach from grounded surfaces, are guarded against contact by persons.

Order 13–2534. Spacing from Lightning Rods.

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

EQUIPMENT

Order 13-2541. Exposed Metal.

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

Order 13-2542. Fixed Equipment.

General. Under any of the following conditions, exposed, non-current-carrying metal parts of fixed equipment, which are liable to become energized, shall be grounded:

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

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

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

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

E. If equipment is in a hazardous location; see Section 13-500;

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

G. If equipment operates with any terminal at more than 150 volts to ground, except as follows:

1. Enclosures for switches or circuit-breakers where accessible to qualified persons only;

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

3. Transformers mounted on wooden poles at a height of more than 8 feet from the ground. See Order 1033-B, Volume 1.

Order 13-2543. Fixed Equipment.—Specific

Specific. Exposed, non-current-carrying metal parts of the following kinds of equipment, regardless of voltage, shall be grounded:

A. Frames of motors as specified in Order 13-4436;

B. Controller cases for motors, except lined covers of snap switches;

C. Electric equipment of elevators and cranes;

D. Electric equipment in garages, theatres and motion picture studios, except pendent lamps on circuits of not more than 150 volts to ground;

E. Motion picture projection equipment;

F. Electric signs and associated equipment, unless these are inaccessible to unauthorized persons and are also insulated from ground and from other conductive objects;

G. Generator and motor frames in an electrically operated organ, unless the generator is effectively insulated both from ground and from the motor driving it;

H. Switchboard frames and structures supporting switching equipment, except that frames of direct-current, single-polarity switchboards need not be grounded if effectively insulated;

I. X-ray tubes used in therapy. For exceptions see Order 13-6633.

For instruments, meters and relays, see Orders 13-2622 to 13-2624.

Order 13-2544. Non-Electrical Equipment.

The following metal parts shall be grounded:

A. Frames and tracks of electrically operated cranes;

B. The metal frame of a non-electrically driven elevator car to which electric conductors are attached;

C. Hand-operated metal shifting ropes or cables of electric elevators;

D. Metal enclosures such as partitions, grill work, etc., around equipment carrying voltages in excess of 750 volts between conductors, unless in substations or vaults under the sole control of the supply company.

Order 13-2545. Portable Equipment.

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

A. In hazardous locations;

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

1. Motors, if guarded;

2. Metal frames of electrically-heated appliances exempted by Order 13-4238;

3. Enclosures for X-ray tubes used in therapy exempted by Order 13-6633.

C. In other than residential occupancies, exposed metal parts of portable appliances used in damp or wet locations, or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers, shall be grounded, except where supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

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

It is recommended that the non-current carrying metal parts of all portable motors and other electrically operated equipment which operate at more than 50 volts and less than 150 volts to ground be grounded.

Order 13-2546. Spacing from Lightning Rods.

Metal frames and cases of electric equipment shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together.

METHODS OF GROUNDING

Order 13–2551. Effective Grounding.

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

Order 13–2552. Grounding Conductor to Circuit.

The grounding conductor may be connected to the grounded circuit conductor at any convenient point on the premises on the supply side of the service disconnecting means.

Order 13–2553. Common Grounding Conductor.

The grounding conductor for circuits may also be used for grounding equipment, conduit and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment.

Order 13–2554. Common Grounding Electrode.

Where the alternating-current system is connected to a grounding electrode in or at a building as specified in Orders 13–2523 and 13–2524, the same electrode shall be used to ground wire enclosures and equipment in or on that building.

Order 13–2555. Underground Service.

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

Order 13–2556. Short Sections of Raceway.

Isolated sections of metal raceway or cable armor, if required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with Order 13–2557.

Order 13–2557. Fixed Equipment.

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

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

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

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

Order 13–2558. Equipment on Structural Metal.

Electrical equipment secured to and in contact with the grounded structural metal frame of a building, shall be deemed to be grounded. Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded if the machine is grounded in accordance with this code.

Order 13–2559. Portable Equipment.

Non-current-carrying metal parts of portable equipment may be grounded in any one of the following ways:

A. By means of the metal enclosure of the conductors feeding such equipment, provided an approved multi-prong plug or equivalent is used, one prong for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure is attached to the plug and to the equipment by connectors approved for the purpose;

B. By means of a grounding conductor run with the circuit conductors in cable assemblies or flexible cords, provided an approved multi-prong plug or equivalent is used, one prong for the purpose of connecting such grounding conductor to the grounded metal raceway or cable armor; this conductor may be uninsulated but if an individual covering is provided for this conductor, it shall be finished to show a green color;

C. By means of a separate flexible wire or strap, insulated or bare, protected as well as practicable against mechanical injury.

Order 13–2560. Frames of Electric Ranges.

Frames of electric ranges shall be grounded by any of the means provided for in Orders 13–2557 and 13–2559, or they may be grounded by connection to the grounded circuit conductors.

Order 13–2561. Grounding Equipment to Circuit Conductor.

The grounded service conductor on the supply side of the service disconnecting means may be used for grounding meter housing and service equipment. The grounded circuit conductor on the load side of the service disconnecting means shall not be used for grounding equipment, cable armor, or metal raceways except as provided in paragraph C of Order 13–2557 and in Order 13–2560.

BONDING

Order 13–2571. Bonding at Service Equipment.

Where the supply is from an overhead distribution system the electrical continuity of the grounding circuit for the following equipment and enclosures shall be assured by one of the means given in Order 13–2572:

A. 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 which forms part of the grounding conductor to the service raceway.

Order 13–2572. Means of Assuring Continuity.

Electrical continuity at service equipment shall be assured by one of the following means:

A. Bonding equipment to the grounded service conductor in a manner provided in Order 13–2613.

B. Threaded couplings and threaded bosses on enclosures with joints made up tight where rigid conduit is involved.

C. Threadless couplings made up tight for rigid conduit and electrical metallic tubing.

D. Bonding jumpers meeting the other requirements of this section. Bonding jumpers shall be used around concentric or eccentric knockouts which are punched or otherwise formed so as to impair the electrical connection to ground.

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

Order 13–2573. Metal Armor or Tape of Service Cable.

With service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armor or tape, the metal covering is considered to be adequately grounded.

Order 13–2574. Voltages Exceeding 150 Volts.

The electrical continuity of metal raceway or metal sheathed cable which contains any conductor of more than 150 volts to ground shall be assured by one of the methods specified in Order 13–2572 B, C, D and E or by one of the following methods:

A. Threadless fittings, made up tight, with conduit or armored cable;

B. Two locknuts, one inside and one outside of boxes and cabinets.

Order 13–2575. Loosely-Jointed Metal Raceways.

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

Order 13–2576. Hazardous Locations.

In hazardous locations, regardless of the voltage involved, the electrical continuity of metallic raceway, boxes and the like, shall be assured by one of the methods specified in sub-paragraphs B, C, D and E of Order 13–2572.

Order 13–2577. Bonding Jumpers.

Bonding jumpers shall conform to the following:

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

B. Attachment. Bonding jumpers shall be attached to cabinets and the like in a manner provided in Order 13–2613; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in Order 13–2614.

GROUNDING ELECTRODES

Order 13–2581. Water Pipe.

A metallic underground water piping system, either local or supplying a community, shall always be used as the grounding electrode where such a piping system is available. If the buried portion of the metallic piping system is less than 50 feet excluding well casings, or has a resistance to ground of more than 3 ohms, the piping system ground shall be augmented by at least 2 grounding electrodes recognized in Order 13–2583 wherever the circuit or non-current carrying parts are required to be grounded.

Order 13–2582. Other Available Electrodes.

Where a water system as described in Order 13–2581 is not available, the grounding connection may be made to any of the following if the resistance to ground is less than 3 ohms or the metal is supplemented by two electrodes of the type recognized in Order 13–2583:

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

B. A continuous metallic underground gas piping system;

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

Order 13–2583. Made Electrodes.

Where electrodes described in Orders 13–2581 and 13–2582 are not available, the grounding electrode shall consist of a driven pipe, driven rod, buried plate or other device approved for the purpose and conforming to the following requirements:

A. *Plate Electrodes.* Each plate electrode shall present not less than 2 square feet of surface to exterior soil. Electrodes of iron, or steel plates shall be at least ¼ inch in thickness. Electrodes of non-ferrous metal shall be at least 0.06 inch in thickness.

B. *Pipe Electrodes.* Electrodes of pipe or conduit shall be not smaller than of the ¾-inch trade size and, if of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

C. *Rod Electrodes.* Electrodes of rods of steel or iron shall be at least ⅝ inch in diameter. Approved rods of non-ferrous materials or

their approved equivalent used for electrodes shall be not less than ½ inch in diameter.

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

Exception: 1. In basements where an 8 foot rod or pipe cannot be driven because of the low ceiling height and where the basement floor level is at least 2 feet below the surrounding outside soil, a rod or pipe driven to a depth of 6 feet may be used.

Order 13-2584. Resistance.

If the resistance to ground of an underground piping or metallic system is more than 3 ohms, two made electrodes must be added to the grounding electrodes. If a single made electrode does not have a resistance to ground of less than 25 ohms, two made electrodes shall be installed. The distance between made electrodes shall be at least 6 feet.

Order 13-2585. Railway Tracks.

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

Order 13-2586. Use of Lightning Rods.

Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes required by this section for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. (See Order 13-8041 B-5.)

GROUNDING CONDUCTORS

Order 13-2591. Material.

The material for the grounding conductors shall be as follows:

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

B. *For Conductor Enclosures and Equipment Only.* The grounding conductor for equipment, and for conduit and other metal raceways or enclosures for conductors, may be a conductor of copper or other corrosion-resistant material, stranded or solid, insulated or bare, a bus bar or other conductor, or a rigid conduit, steel pipe or electrical metallic tubing, except that under conditions favorable to corrosion the grounding conductor shall be of copper or other corrosion-resistant material.

Order 13-2592. Installation.

A grounding conductor, No. 4 or larger, may be attached to the surface on which it is carried without the use of knobs, tubes or insulators. It need not have protection unless exposed to severe mechanical injury. A No. 6 grounding conductor, which is free from exposure to mechanical injury, may be run along the surface of the building construction without metal covering or protection, if it is rigidly stapled to the construction; otherwise, it shall be in conduit, electrical metallic tubing or cable armor. Grounding conductors smaller than No. 6 shall be in conduit, electrical metallic tubing or cable armor. Metallic enclosures for grounding conductors shall be continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Where rigid metallic conduit or steel pipe is used as a grounding conductor, the installation shall comply with the requirements of Section 13-346; where electrical metallic tubing is used, the installation shall comply with the requirements of Section 13-348.

Order 13-2593. Direct-Current Circuits.

The carrying capacity of the grounding conductor for a direct-current supply system or generator shall be not less than that of the largest conductor supplied by the system, except where the grounded circuit conductor is a neutral derived from a balancer winding or a balancer set protected in accordance with requirements of paragraph C of Order 13-4454, the size of the grounding conductor shall not be less than that of the neutral conductor. The grounding conductor shall in no case be smaller than No. 8 copper.

Order 13–2594. Alternating-Current Circuits and Service Equipment.

A. *Wiring System and Common Grounding Conductor.* The size of the grounding conductor for an alternating-current system or for a common grounding conductor shall not be less than is given in the following table, except that where connected to made electrodes (as in Order 13–2583) the conductor need not be larger than No. 6 copper wire or its equivalent in carrying capacity.

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

B. If the wiring system is not grounded at the premises, the size of a grounding conductor for a service raceway, for the metal sheath or armor of a service cable, and for service equipment shall be not less than is given in the following table, except that where connected to made electrodes (as in Order 13–2583) the conductor need not be larger than No. 6 copper or its equivalent in carrying capacity.

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Grounding Conductor		
	Copper Wire AWG. No.	Conduit or Pipe Trade Size (inch)	Electrical Metallic Tubing Trade Size (inch)
2 or smaller	8	½	½
1 or 0	6	½	½
00 or 000	4	½	1
Over 000 to 350,000 c.m.	2	¾	1¼
Over 350,000 c.m. to 600,000, c.m.	0	¾	1¼
Over 600,000 c.m. to 1,100,000 c.m.	00	1	2
Over 1,100,000 c.m.	000	1	2
		1	2

Order 13–2595. Interior Raceway and Equipment.

The size of the grounding conductor for conduit, cable sheath or armor, and other metal raceways or enclosures for conductors, and for equipment, shall be not less than given in the following table, except that where connected to electrodes as described in Order 13–2583, the grounding conductor need not be larger than No. 6 copper or its equivalent:

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size of Grounding Conductor		
	Copper Wires No.	Conduit or Pipe (Inch)	Electrica Metallic Tubing (Inch)
20	16*	½	½
30	14	½	½
40	12	½	½
60	10	½	½
100	8	½	½
200	6	½	½
400	4	¾	1
600	2	¾	1¼
800	0	¾	1¼
1000	00	1	2
1200	000	1	2
		1	2

*Permissible only when part of an approved cable assembly.

Order 13–2596. Portable and Pendent Equipment.

For grounding portable or pendent equipment, the conductors of which are protected by fuses or circuit-breakers rated or set at not exceeding 20 amperes, No. 18 copper wire may be used. Conductors of Nos. 16 or 18 copper which are used for grounding portable equipment shall be part of an approved flexible cord assembly. For grounding portable or pendent equipment protected at more than 20 amperes, the table in Order 13–2595 shall be followed.

Order 13–2597. Outline Lighting.

Isolated non-current-carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from mechanical injury, if a conductor complying with Order 13–2595 is used to ground the group.

Order 13–2598. Common Raceway.

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

Order 13–2599. Continuity.

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

GROUNDING CONDUCTOR CONNECTIONS

Order 13–2611. Grounding Conductor to Raceway.

The point of connection of the grounding conductor to interior metal raceways, cable armor and the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in Order 13–2595.

Order 13–2612. Grounding Conductor to Electrode.

The grounding connection to the electrode shall be located as follows:

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

B. *To Gas Pipes.* The point of attachment of a grounding conductor to gas piping shall always be on the street side of the gas meter, and shall be accessible where practicable.

C. *To Other Electrodes.* The grounding conductor shall be attached to other electrodes permitted in Orders 13-2582 and 13-2583 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

Order 13-2613. Attachment to Circuits and Equipment.

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

Order 13-2614. Attachment to Electrodes.

The grounding conductor shall be attached to the grounding electrode by means of (1) an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron, or (2) a pipe fitting, plug, or other approved device, screwed into the pipe or into the fitting, or (3) other equally substantial approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting, unless the clamp or fitting is of a type approved for such use.

Order 13-2615. Ground Clamps.

For the grounding conductor of a wiring system the sheet metal strap type of ground clamp is not considered adequate unless it has a rigid metal base seated on the water pipe or other electrode and the strap is of such material and dimensions that it is not liable to stretch during or after installation.

Ground clamps for use on copper water tubing and copper, brass, or lead pipe should preferably be of copper, and those for use on galvanized or iron pipe should preferably be of galvanized iron and so designed as to avoid mechanical injury to pipe.

Order 13-2616. Protection of Attachment.

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

Order 13-2617. Clean Surfaces.

If a non-conductive protective coating such as paint or enamel, is used on the equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good electrical connection.

INSTRUMENT TRANSFORMERS, RELAYS, ETC.

Order 13-2621. Instrument Transformer Circuits.

The secondary circuits of current and potential instrument transformers shall be grounded if the primary windings are connected to circuits of 300 volts or more to ground, and, if on switchboards, shall be grounded irrespective of voltage.

Order 13-2622. Instrument Transformer Cases.

Cases or frames of instrument transformers shall be grounded, except that cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters, need not be grounded.

Order 13-2623. Cases of Instruments, Meters and Relays.

Operating Voltage 750 or Less. Instruments, meters and relays which operate with windings or working parts at 750 volts or less shall be grounded as follows:

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

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

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

Order 13-2624. Cases of Instruments, Meters and Relays.

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

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

Order 13-2625. Instrument Grounding Conductor.

The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12, if of copper, or, if of other metal, shall have equal conductance.

LIGHTNING ARRESTERS

Order 13-2631. On Secondary Services, 750 Volts or Less.

Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor, or (4) a separate grounding conductor. The bonding or grounding conductor shall be of copper not smaller than No. 14 or of equivalent corrosion-resistant material.

Order 13-2632. On Primary Circuits.

The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected solidly or through a gap with the grounded conductor of such transformer, provided that in addition to the direct grounding connection at the arrester either:

1. The secondary has elsewhere 2 grounding connections at least 20 feet apart to extended underground water piping systems or to artificial grounds complying with Order 1038. One or both of these connections may be at customers' entrances.

2. The secondary neutral is common with the primary neutral and is grounded in the manner indicated in Order 1031, B, 5.

Note: See definition of lightning arrester Order 1020.

SECTION 13-280. LIGHTNING ARRESTERS INDUSTRIAL STATIONS

Order 13-2801. Where Required.

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

For lightning arresters in hazardous locations, see Section 13-500.

Order 13-2802. Number Required.

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

Order 13-2803. Where Connected.

The arrester shall be connected on the line side of all connected station apparatus.

OTHER OCCUPANCIES

Order 13-2811. Utilization Equipment.

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

GENERAL

Order 13-2821. Location.

Indoors. Arresters installed indoors shall be located well away from other equipment, passageways and combustible parts of buildings, and if containing oil shall be separated from other equipment by walls meeting the requirements of Order 13-4542.

Order 13-2822. Location.

Outdoors. If arresters containing oil are located outdoors, provision shall be made to drain away any accumulation of oil.

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

Order 13-2823. Connections.

The connections between the arrester and the line wire or bus, and between arrester and ground shall be of copper wire or cable or the equivalent, and, except as provided on secondary services in Order 13-2631, shall not be smaller than No. 6, and shall be made as short and as straight as practicable, avoiding as far as possible all bends and turns, especially sharp bends.

Order 13-2824. Insulation.

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

Order 13-2825. Isolating Switch.

If isolating switches or disconnecting devices are used, they shall withstand, in full open position, a voltage test between live parts 10 per cent in excess of the maximum voltage test they will withstand to ground.

Order 13-2826. Grounding.

Lightning arresters shall be grounded in the manner prescribed in Section 13-250.

Chapter 3. Wiring Methods and Materials

SECTION 13-300. GENERAL REQUIREMENTS FOR WIRING METHODS

On premises where a continuous extensive underground metallic water-piping network system is not available as a grounding electrode, and where it is not practicable otherwise to secure a ground of permanently low resistance (below 3 ohms), the use of a wiring method which does not employ metal enclosures for the wires is recommended, unless the character or occupancy of the building is such as to require the use of a metal-enclosed wiring system. In general, metallic raceway systems should not be used for the interior wiring but may be used for the service entrance.

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

Order 13-3001. Scope.

The provisions of Orders 13-3002 to 13-3020 inclusive, shall apply to all wiring installations, except for remote-control, low-energy power and signal systems as provided in Section 13-725, and communication systems as provided in Section 13-800.

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

Order 13-3002. Voltage Limitations.

Wiring methods specified in Chapter 3 may be used for voltages not exceeding 600, unless specifically limited in some section of Chapter 3, and may be used for voltages over 600 where specifically permitted elsewhere in this code.

Order 13-3003. Protection Against Corrosion and Mechanical Injury.

Conductors and equipment shall be protected against corrosion and mechanical injury in accordance with the following:

A. *Corrosion.* Metal raceways, cable armor, boxes, cabinets and all metallic elbows, couplings, and fittings, unless made of corrosion-resistant material, shall be suitably protected against corrosion inside and outside (except threads at joints) by a coating of approved corrosion-resistant materials such as zinc, cadmium, or enamel; except that ferrous raceways, fittings and boxes protected from corrosion solely by enamel may be used only indoors and in occupancies not subject to severe corrosive influences. Where enameled conduit is not permitted, exposed threads shall be protected with a corrosion resistant coating after installation.

See Order 13-3462 for conduit, and Order 13-3482 for electrical metallic tubing.

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

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

Order 13-3004. Secured in Place.

Raceways, cable assemblies, boxes, cabinets and fittings shall, unless otherwise provided, be securely fastened in place. Raceways and cable assemblies shall be mechanically secured to boxes, fittings, cabinets and other enclosures, except as provided for nonmetallic boxes in Order 13-3710.

Order 13-3005. Runs Continuous.

Raceways and cable assemblies shall be continuous from outlet to outlet and from fitting to fitting. Conductors shall be continuous from outlet to outlet and, except as permitted for auxiliary gutters in Order 13-3748, and for wireways in Order 13-3625, there shall be no splice or tap within the raceway itself.

Order 13-3006. Free Length of Conductors at Outlets.

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

Order 13-3007. Boxes at Outlets.

Except as permitted in Order 13-3369, a box shall be installed at each outlet, switch, or junction point of conduit, electrical metallic tubing, surface metal raceway, armored cable, or non-metallic sheathed cable, and at each outlet and switch point of concealed knob-and-tube work.

Order 13-3008. Boxes and Fittings Where Conductors Are Brought Out.

Except as provided in Order 13-3009, a box or terminal fitting having a separately bushed hole for each conductor shall be used wherever a change is made from conduit, electrical metallic tubing, non-metallic sheathed cable, armored cable and surface metal raceway wiring to open wiring or to concealed knob-and-tube work. A fitting used for this purpose shall contain no taps or splices and shall not be used at fixture outlets.

Order 13-3009. Bushing in Lieu of Box or Fitting.

A bushing may be used in lieu of a box or terminal fitting at ends of conduit or electrical metallic tubing where conductors leave the conduit or tubing behind a switchboard, or where more than 4 con-

ductors leave the conduit or tubing at control apparatus or in similar locations, in which case the conductors shall be bunched, taped and painted with insulating paint. Such a bushing shall be of the insulating type except for lead-covered conductors.

Order 13-3010. Through Studs, Joists and Rafters.

When, in exposed or concealed work, conductors in insulating tubes or cables are run through bored holes in studs, joists or similar wood members, holes shall be bored at the approximate centers of wood members, or at least two inches from the top edge. Where there is no objection because of weakening the building structure, armored or non-metallic sheathed cable may be laid in notches no more than ¼ span from either end in the studding or joists if the cable at those points is protected against the driving of nails into it by having the notch covered with a steel plate at least 1/16 inch in thickness before building finish is applied.

Order 13-3011. Conductors of Different Systems.

Conductors of signal or radio systems shall not occupy the same enclosure with conductors of light or power systems except as permitted for elevators in Orders 13-6216 and 13-6217; for sound recording in Order 13-6405; for remote-control, low-energy power and signal circuits in Orders 13-7266 and 13-7292; and communication system in Orders 13-8012 and 13-8031. Secondary wiring to electric discharge lamps of 1,000 volts or less may occupy the same enclosure as the branch circuit conductors. Conductors of light and power systems of 600 volts or less may occupy the same enclosure, without regard to whether the individual circuits are alternating-current or direct-current, only if all conductors are insulated for the maximum voltage of any conductor within the enclosure. Conductors of light and power systems of over 600 volts shall not occupy the same enclosure with conductors of light and power systems of 600 volts or less. Control, relay and ammeter conductors used in connection with any motor or starter may occupy the same enclosure as the motor circuit conductors.

Order 13-3012. Number of Conductors in Raceway.

In general the percentage of the total interior cross-sectional area of a raceway occupied by conductors shall not be more than will permit a ready installation or withdrawal of the conductors and dissipation of the heat generated without injury to the insulation of the conductors. See the following orders of this code: conduit, Order 13-3466; electrical metallic tubing, 13-3486; surface metal raceways, 13-3524; underfloor raceways, 13-3545; cellular metal floor raceways, 13-3564; wireways, 13-3624; auxiliary gutters, 13-3745; theatres, 13-5212; signs, 13-6021-D; elevators, 13-6214; and sound recording, 13-6403 and 13-6404.

Order 13-3013. Inserting Conductors in Raceways.

Raceways, except those used for exposed work and having a removable cover or capping, shall first be installed as a complete raceway

system without the conductors. Conductors shall not be inserted until all mechanical work on the building which is liable to injure the conductors has been completed, as far as possible. Pull wires, if used, shall not be installed until the raceway system is in place. Graphite, talc, or an approved compound may be used as a lubricant in inserting conductors in raceways. Cleaning agents or lubricants having a deleterious effect on conductor coverings shall not be used.

Order 13-3014. Supporting Vertical Conductors in Raceways.

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

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

The following methods of supporting cables are recommended:

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

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

C. In junction boxes, by deflecting the cables not less than 90 degrees and carrying them horizontally to a distance not less than twice the diameter of the cable, the cables being carried on two or more insulating supports, and additionally secured thereto by tie wires if desired.

Order 13-3015. Raceways Exposed to Different Temperatures.

If portions of an interior raceway system are exposed to widely different temperatures, as in refrigerating or cold storage plants, provision shall be made to prevent circulation of air from a warmer to a colder section through the raceway.

Order 13-3016. Electrical Continuity of Raceways.

Interior metal raceways, cable armor, and other metal enclosures for conductors, shall be metallically joined together into a continuous electrical conductor, and shall be so connected to all boxes, fittings and cabinets as to provide effective electrical continuity.

Order 13-3017. Grounding Metal Enclosures.

Metal raceways, cable armor and fittings shall be grounded if and as prescribed in Section 13-250.

Order 13-3018. Alternating-Current Systems in Metal Enclosures.

Where run in metal raceway or cable armor, or where a current of more than 50 amperes enters a metal enclosure, the conductors of

circuits operating on alternating-current shall be so arranged as to avoid overheating of the metal by induction. If the capacity of a circuit is such that it is impracticable to run all conductors in one enclosure, additional enclosures may be used provided the conductors in any one enclosure are balanced in size and include one from each phase.

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

In the case of circuits supplying vacuum or electric discharge lighting systems or signs, or X-ray apparatus, and under-plaster extensions permitted by Orders 13-3441 to 13-3444 inclusive, the currents carried by the conductors are so small that a single conductor may be placed in a metal raceway or cable armor without causing trouble from induction.

Where the conductors of a circuit pass through individual holes in the wall of a metal cabinet, the effect of induction may be eliminated by cutting slots in the metal between the individual holes through which the conductors of the circuit pass, or by passing all the conductors in the circuit through an insulating block, used to cover a hole in the metal cabinet sufficiently large for all the conductors of the circuit, and providing individual holes in the insulating block for the separate conductors.

Order 13-3019. Underground Runs.

Conductors run underground shall comply with the provisions of Orders 13-2311, 13-2312 and 13-2313 as far as mechanical protection is concerned.

Order 13-3020. Wiring in Ventilating Ducts.

Electrical installations shall be so made that the possible spread of fire through fire-stopped partitions, hollow spaces, fire walls or fire partitions, vertical shafts, ventilating or air-conditioning ducts is reduced to a minimum. No wiring system of any type shall be installed in ducts for dust, loose stock or vapor removal. Where it is necessary to run a wiring system through air-conditioning ducts or plenum chambers, the wiring method shall be rigid conduit, flexible steel conduit with lead-covered conductors, or Type ACL armored cable, with fittings suitable for the location. The terminals of circuits of such wiring systems shall be so located that it will not be necessary to install motors or control equipment in the ducts, except for temperature and humidity control. Raceways shall not interfere with the operation of automatic fire dampers in ducts.

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

SECTION 13-310—CONDUCTORS

Order 13-3101. General.

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

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

Order 13-3102. Conductor Insulation.

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

Trade Name	Type Letter	Max. Operating Temp.	Special Provisions
Rubber-Covered Fixture Wire	RF-64	60C 140F	Fixture wiring. Limited to 300 V.
Solid or Stranded	RF-32	60C 140F	Fixture wiring, and as permitted in order 13-3103.
Rubber-Covered Fixture Wire	FF-64	60C 140F	Fixture wiring. Limited to 300 V.
Flexible Stranding	FF-32	60C 140F	Fixture wiring.
Latex Rubber Fixture Wire, Solid or Stranded	RUF	60C 140F	Fixture wiring, and as permitted in order 13-3103.
Flexible Stranding	RUFF	60C 140F	Fixture wiring.
Thermoplastic-Covered Fixture Wire—Solid or Stranded	TF	60C 140F	Fixture wiring, and as permitted in order 13-3103.
Thermoplastic-Covered Fixture Wire—Flexible Stranding	TFF	60C 140F	Fixture wiring.
Cotton-Covered, Heat-Resistant, Fixture Wire	CF	90C 194F	Fixture wiring. Limited to 300 V.
Asbestos-Covered Heat-Resistant, Fixture Wire	AF	150C 302F	Fixture wiring. Limited to 300 V.
Code Rubber	R	60C 140F	General use.
Heat-Resistant Rubber	RH	75C 167F	General use.
Moisture-Resistant Rubber	RW	60C 140F	General use and wet locations.
Latex Rubber	RU	60C 140F	General use.
Moisture-Resistant Latex Rubber	RUW	60C 140F	General use and wet locations.
Thermoplastic	T	60C 140F	General use
Moisture-Resistant Thermoplastic	TW	60C 140F	General use and wet locations.
Thermoplastic and Asbestos	TA	90C 194F	Switchboard wiring only.
Varnished Cambric	V	85C 185F	Dry locations only. Smaller than No. 6 by special permission.
Asbestos and Varnished Cambric	AVA	110C 230F	Dry locations only.
Asbestos and Varnished Cambric	AVL	110C 230F	Wet locations.
Asbestos and Varnished Cambric	AVB	90C 194F	Dry locations only.
Asbestos	A	200C 392F	Dry locations only. Not for general use. In raceways, only for leads to or within apparatus. Limited to 300 V.

Trade Name	Type Letter	Max. Operating Temp.	Special Provisions
Asbestos	AA	200C 392F	Dry locations only. Open wiring. Not for general use. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AI	125C 257F	Dry locations only. Not for general use. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AIA	125C 257F	Dry locations only. Open wiring. Not for general use. In raceways, only for leads to or within apparatus.
Paper		85C 185F	For underground service conductors, or by special permission.
Slow-Burning	SB	90C 194F	Dry locations only. Open wiring; and in raceways where temperatures will exceed those permitted for rubber-covered or varnished cambric-covered conductors.
Slow-Burning Weatherproof	SBW	90C 194F	Dry locations only. Open wiring only.
Weatherproof	WP	80C 176F	Open wiring by special permission where other insulations are not suitable for existing conditions.

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

Thermoplastic insulation may stiffen at temperatures below minus 10°C (14°F) and care should be used in its installation at such temperatures. It may be deformed when subject to pressure; care should be taken in its installation, as for example, at bushings, or points of support. See order 13-3736B.

For size of conductors recognized for the various insulating coverings, and for construction details, see order 13-93101.

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

B. *Wet Locations.* Insulated conductors used underground, in concrete slabs or other masonry in direct contact with earth, in wet locations, or where condensation or accumulation of moisture within the raceway is likely to occur, shall be moisture-resistant, rubber-covered (type RW); moisture-resistant, thermoplastic-covered (type TW); lead-covered; or of a type approved for the purpose.

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

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

Order 13-3103. Minimum Size of Conductors.

Conductors, whether solid or stranded, shall not be smaller than No. 14, except for printing press control circuits; as provided for flexible cords in Order 13-4006; for fixture wire in Order 13-4142; for fractional horsepower motors in Order 13-4312; for cranes and hoists in Order 13-6112; for elevator control and signal circuits in Order 13-6205; for machine tools in Order 13-6721; and for remote-control, low-energy power and signal circuits in Order 13-7263.

Order 13-3104. Stranded Conductors.

Except when used as bus bars, conductors No. 6 and larger, installed in raceways, shall be stranded.

Order 13-3105. Conductors in Multiple.

Conductors in sizes 1/0 to 500,000 c.m., inclusive, may be run in multiple provided they are of the same length and have the same circular-mil area and type of insulation. Not more than three No. 1/0, four No. 2/0 nor five Nos. 3/0 to 50,000 c.m. conductors, inclusive, may be run in multiple. Except as herein provided, conductors shall be run in multiple only by special permission or as permitted in Order 13-6205. Where conductors are run in multiple, they shall be arranged and terminate at both ends in such a manner as to insure equal division of the total current between all conductors that are involved.

Order 13-3106. Current-carrying Capacity.

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

SECTION 13-320. OPEN WIRING ON INSULATORS

Order 13-3201. Scope.

Opening wiring on insulators shall comply with the provisions of Orders 13-3001 to 13-3020 inclusive and shall also comply with the provisions of the following Orders 13-3202 to 13-3215 inclusive.

Order 13-3202. Use.

Open wiring on insulators shall not be used (1) in commercial garages, (2) in theaters, (3) in motion picture studios, (4) in hoistways, and (5) in hazardous locations, except in storage compartments of Class III locations as provided in paragraph B of Order 13-5073.

Order 13-3203. Types of Conductors.

The type of conductors shall conform to Section 13-310. Only single conductors shall be used.

Order 13-3204. Supports.

Conductors shall be supported in accordance with the following:

A. Open conductors shall be rigidly supported on non-combustible, non-absorptive insulating material, except as provided in Order 13-3206.

B. Rigid supporting requires, under ordinary circumstances, if wiring over flat surfaces, supports at least every 4½ feet, this interval

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

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

Order 13-3205. Spacing.

Open conductors in dry places and for voltages not exceeding 300 volts shall be separated 2½ inches from each other and ½ inch from the surface wired over; and, except as provided in paragraph B of Order 13-3204, for voltages from 301 to 600 volts shall be separated 4 inches from each other and 1 inch from the surface wired over. In damp or wet locations a separation of at least 1 inch from the surface wired over shall be maintained for all voltages.

Order 13-3206. Flexible Tubing.

In dry locations, where not exposed to severe mechanical injury, conductors may be separately encased in flexible tubing. Tubing shall be in continuous length not exceeding 15 feet, and secured to the surface wired over by straps spaced not exceeding 4½ feet apart.

Order 13-3207. Dead Ends.

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

Order 13-3208. Tie Wires.

No. 8 or larger conductors supported on solid knobs shall be securely tied thereto. If conductors are used for tying, they shall have an insulation of the same type as that of the conductors which they confine.

Order 13-3209. Passing Through Walls and Floors.

Open conductors shall be separated from contact with walls, floors, timbers or partitions through which they pass by tubes or bushings of non-combustible, non-absorptive insulating material. If the bushing is shorter than the hole, a waterproof sleeve of non-inductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at either end in such a manner as to keep the conductors

absolutely out of contact with the sleeve. Each conductor must be carried through a separate porcelain tube or sleeve.

Order 13-3210. Separation from Metal Work.

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

Order 13-3211. Separation from Piping in Damp Locations.

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

Order 13-3212. Protection from Mechanical Injury.

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

A. By guard strips not less than ⅞ inch in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring.

B. By a substantial running board at least ½ inch thick back of the conductors with side protections. Running boards shall extend at least 1 inch outside the conductors, but not more than 2 inches and the protecting sides shall be at least 2 inches high and at least ⅞ inch thick.

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

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

Order 13-3213. In Accessible Attics.

Conductors in unfinished accessible attics or roof spaces shall be installed in accordance with the requirements of Order 13-3247.

Order 13-3214. In Concealed Spaces.

Conductors shall not be in contact with any object other than their insulating supports. If run in concealed spaces they shall be installed

as required for concealed knob-and-tube work in accordance with the provisions of Orders 13-3241 to 13-3248 inclusive.

Order 13-3215. Entering Spaces Subject to Dampness, Wetness or Corrosive Vapors.

Conductors entering or leaving locations subject to dampness, wetness or corrosive vapors shall have drip loops formed on them and shall then pass upward and inward from the outside of buildings, or from the damp, wet, or corrosive location, through non-combustible, non-absorptive insulating tubes.

SECTION 13-324. CONCEALED KNOB-AND-TUBE WORK

Order 13-3241. Scope.

Concealed knob-and-tube work shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and shall also comply with the provisions of the following Orders 13-3242 to 13-3248 inclusive.

Order 13-3242. Use.

Concealed knob-and-tube work may be used in the hollow spaces of walls and ceilings. It shall not be used (1) in commercial garages, (2) in theaters except as provided in 13-5211, (3) in motion picture studios, nor (4) in hazardous locations.

Order 13-3243. Type of Conductor.

The type of conductors shall conform to Section 13-310. Only single conductors shall be used.

Order 13-3244. Supports.

Conductors shall be supported at intervals not exceeding 4½ feet by knobs and tubes. There shall be a knob within 6 inches from each tap. Tie wires shall comply with Order 13-3208. If such support is impracticable and the conductors are in a dry location, they may be fished if separately enclosed in flexible tubing extending in continuous lengths from one support to the next or to an outlet box, or from one outlet box to another. Otherwise, conduit, armored cable, electrical metallic tubing or non-metallic sheathed cable shall be used.

Order 13-3245. Conductor Separation.

Conductors shall be separated at least 3 inches and maintained at least 1 inch from the surface wired over. At distributing centers, meters, outlets, switches or other places where space is limited and the 3 inch separation cannot be maintained, each conductor shall be encased in a continuous length of flexible tubing. Where practicable, conductors shall be run singly on separate timbers or studding.

Order 13-3246. Separation from Other Objects and Protection.

Conductors shall be separated from other conductors and objects as follows:

A. The provisions as to rigid supporting and clearance from foreign wires and other objects, as specified for open wiring in Orders 13-3209, 13-3210, 13-3211, and 13-3215 shall be complied with.

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

Order 13-3247. In Unfinished Attics and Roof Spaces.

Conductors in unfinished attics or roof spaces shall comply with the following:

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

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

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

Order 13-3248. Boxes of Insulating Material.

Non-metallic outlet boxes may be used as provided in Order 13-3703.

SECTION 13-328. BARE-CONDUCTOR FEEDERS

Order 13-3281. Use.

By special permission, bare conductors installed in accordance with the provisions of Orders 13-3001 to 13-3020, inclusive, and in accordance with the provisions of the following Orders 13-3282 to 13-3287, inclusive, may be used for feeders only. Such bare conductors may be installed only in a chase, channel or shaft of non-combustible material in a building of fire-resistive construction; and only if the voltage between conductors does not exceed 600 volts. Bare conductors shall not be used in damp or wet locations, nor in any hazardous location, nor where subject to corrosive vapor, except in storage battery rooms as provided in Order 13-4807.

Order 13-3282. Size and Capacity of Conductors.

The maximum permissible current shall be 1000 amperes per square inch of cross-sectional area of conductor in unventilated enclosures, and 1200 amperes per square inch in ventilated enclosures.

Order 13-3283. Branch Taps.

Branch taps from bare-conductor feeders may be installed as specified in Order 13-2434; provided that the mechanical protection specified by sub-paragraphs C or D of Order 13-2434 shall not be required for that portion of the conductor located in the chase, channel or shaft.

Order 13-3284. Accessibility.

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

Order 13-3285. Supports.

Conductors shall be supported as follows:

A. Conductors shall be supported on non-combustible non-absorptive insulating supports of adequate mechanical strength.

B. Conductors shall be so supported that a separation between conductors, and between conductors and ground, of not less than that specified in Order 13-93847 will be maintained under all conditions of operation.

Order 13-3286. Fire Cutoffs.

If floors are pierced, suitable cutoffs against vertical travel of fire shall be provided.

Order 13-3287. Special Safeguards.

In addition to the provisions of the preceding orders, the authority enforcing this code may require other safeguards in view of special conditions that may be met in a particular installation.

SECTION 13-334. ARMORED CABLE

Order 13-3341. Scope.

Installations of armored cable shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and in addition shall comply with the provisions of the following Orders 13-3342 to 13-3348, inclusive.

Order 13-3342. Use.

Armored cable (type AC or ACT) may be used for both exposed work and concealed work in dry locations; for underplaster extensions as provided in Section 13-344; and embedded in plaster finish on brick or other masonry, except in damp or wet locations. Armored cable (type ACV) in sizes No. 4 and larger may be used for exposed work in dry locations in buildings occupied for industrial purposes. Armored cable shall contain lead-covered conductors (type ACL), if used where exposed to the weather or to continuous moisture, for underground runs and embedded in masonry, concrete or fill in buildings in course of construction, or where exposed to oil, gasoline or other conditions having a deteriorating effect on the insulation. Armored cable may be run or fished in the air voids of concrete masonry block or tile walls where such walls are not exposed or subject to excessive moisture or dampness. Armored cable shall not be used (1) in theaters, except as provided in Order 13-5211; (2) in motion-picture studios; (3) in any hazardous locations; (4) where exposed to corrosive fumes or vapors; (5) in storage-battery rooms; (6) on cranes or hoists, except as provided in sub-paragraph 13-6113-C; nor (7) in hoistways or on elevators, except as provided in Order 13-6206.

Order 13-3343. Supports.

Armored cable shall be secured by approved staples, straps, or similar fittings, so designed and installed as not to injure the cable. Cable shall be secured at intervals not exceeding 4½ feet and within 24 inches from every outlet box or fitting, except where cable is fished. Holes through studs, joists and similar members, shall be considered as cable supports.

Order 13-3344. Exposed Work.

Exposed runs of cable shall closely follow the surface of the building finish or of running boards, except:

A. Lengths of not more than 24 inches at terminals where flexibility is necessary.

B. In accessible attics and roof spaces, for which see Order 13-3346.

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

Order 13-3345. Through Studs, Joists and Rafters.

See Order 13-3010.

Order 13-3346. In Accessible Attics.

Cable in accessible attics or roof spaces shall be installed as follows:

A. If run across the top of floor joists, or within 7 feet of floor or floor joist across the face of rafters or studding, the cable shall be protected by substantial guard strips which are at least as high as the cable. If the attic is not accessible by permanent stairs or ladders, protection will only be required within 6 feet of the nearest edge of scuttle hole or attic entrance.

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

Order 13-3347. Protection at Cable Ends.

At all points where the armor terminates, a fitting shall be provided to protect wires from abrasion, unless the design of the outlet boxes or fittings is such as to afford equivalent protection, and in addition, an approved insulating bushing or its equivalent approved protection shall be provided between the conductors and the armor. The connector or clamp by which the armored cable is fastened to boxes or cabinets shall be of such design that the insulating bushing or its equivalent will be visible for inspection. This bushing will not be required with lead covered cables which shall be so installed that the lead sheath will be visible for inspection.

Order 13-3348. Bends.

All bends shall be so made that the armor of the cable will not be injured, and the radius of the curve of the inner edge of any bend shall be not less than 5 times the diameter of the cable.

SECTION 13-336. NON-METALLIC SHEATHED CABLE

Order 13-3361. Scope.

Installations of non-metallic sheathed cable shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and shall also comply with the provisions of the following Orders 13-3362 to 13-3370, inclusive. (See Section 13-560 for farm wiring)

Order 13-3362. Use.

A. Non-metallic sheathed cable having a fibrous or other type of water absorbent covering may be used for both exposed and concealed work in dry locations. Non-metallic sheathed cable shall not be used as service-entrance cable; nor shall it be embedded in masonry, concrete, fill or plaster, nor run in a shallow chase in masonry or concrete walls and covered with plaster or similar finish; nor in contact with outside masonry walls. Non-metallic sheathed cable may be run or fished in the air voids of concrete masonry block or tile walls if such walls are never damp. Non-metallic sheathed cable shall not be installed (1) in commercial garages, (2) in theaters, except as provided in Order 13-5211, (3) in motion picture studios, (4) in storage battery rooms, (5) in hoistways, (6) in any hazardous location, (7) in breweries, ice plants, cold-storage warehouses, (8) in those parts of farm occupancies where animals are housed, pumphouses, unheated underground rooms, wash rooms, cooling rooms, and similar wet or damp locations where subject to mildly corrosive fumes and vapors, or where exposed to the weather.

B. Moisture and Oil Resistant Non-metallic Sheathed Cable. Neoprene Jacketed Cables or equivalent moisture, fungus and oil resistant cable may be used in those parts of farm occupancies where animals are housed, pump houses, unheated underground rooms, wash rooms, cooling rooms, and similar wet or damp locations where subject to mildly corrosive fumes and vapors; and may be installed within the hollow voids of concrete or tile walls or partitions. It shall not be installed (1) in commercial garages, (2) in theaters, except as provided in Order 13-5211, (3) in motion-picture studios, (4) in storage battery rooms, (5) in hoistways, (6) in hazardous locations, (7) in breweries, ice plants, cold-storage warehouses.

Order 13-3363. Supports.

Non-metallic sheathed cable shall be secured by approved staples, straps, or similar fittings, so designed and installed as not to injure the cable. Cable shall be secured in place at intervals not exceeding 4½ feet for fibrous covered non-metallic sheathed cable; 2 feet for 2 conductor and 3 feet for 3 conductor Neoprene Jacketed Cable and within 12 inches from every outlet box or fitting, except that in concealed work in finished buildings where such supporting is impracticable, the cable may be fished from outlet to outlet.

Order 13-3364. Exposed Work—General.

In exposed work, except as provided in Orders 13-3366 and 13-3367, the cable shall be installed as follows:

A. The cable shall closely follow the surface of the building finish or of running boards.

B. It shall be protected from mechanical injury where necessary, by conduit, pipe, guard strips or other means. If passing through a floor the cable shall be enclosed in rigid conduit or pipe extending at least 6 inches above the floor.

Order 13-3365. Through Studs, Joists and Rafters.

See Order 13-3010.

Order 13-3366. In Unfinished Basements.

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

Order 13-3367. In Accessible Attics.

Cable in accessible attics or roof spaces shall be installed as follows:

A. If run across the top of floor joists, or within 7 feet of floor or floor joists, across the face of rafters or studding, the cable shall be protected by substantial guard strips at least as high as the cable. If the attic is not accessible by permanent stairs or ladders, protection will only be required within 6 feet of the nearest edge of scuttle hole or attic entrance.

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

Order 13-3368. Bends.

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

Order 13-3369. Devices of Insulating Material.

Switch, outlet and tap devices of insulating material may be used without boxes in exposed cable wiring. Openings in such devices shall form a close fit around the outer covering of the cable and the device shall fully enclose that part of the cable from which any part of the covering has been removed. If connections to conductors are by binding screw terminals, there shall be available as many screws as conductors, unless cables are clamped within the structure, or unless terminals are of a type approved for the purpose.

Order 13-3370. Boxes of Insulating Material.

Non-metallic outlet boxes approved for the purpose may be used as provided in Order 13-3703.

SECTION 13-338—SERVICE-ENTRANCE CABLE

Types ASE, SE and USE

Order 13-3381. Scope.

Service-entrance cable used as service-entrance conductors shall comply with the provisions of Section 13-230. Service-entrance cable used for interior wiring shall comply with the provisions of Orders 13-3001 to 13-3020 inclusive. Cable with metal interlocking armor shall be installed in accordance with the applicable provisions of Section 13-334. Unarmored cable shall be installed in accordance with the applicable provisions of Section 13-336. Service-entrance cable shall also comply with the provisions of Orders 13-3382 and 13-3383.

Order 13-3382. Use.

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

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

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

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

Order 13-3383. Through Studs, Joists and Rafters.

See Order 13-3010.

SECTION 13-340. NON-METALLIC WATERPROOF WIRING

Order 13-3401. Scope.

Installations of non-metallic waterproof wiring shall comply with the requirements of Orders 13-3001 to 13-3020 inclusive, and in addition the following Orders 13-3402 to 13-3409, inclusive.

Order 13-3402. Use.

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

Order 13-3403. Conductors.

Rubber-sheathed multiple-conductor cable approved for the purpose shall be used. The individual conductors of the cable shall not be smaller than No. 12, except that the cable may contain an approved

size of conductor, with or without individual insulation, to be used for equipment grounding purposes only. See sub-paragraph A of Order 13-2557.

Order 13-3404. Supports.

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

Order 13-3405. Attachment to Fittings.

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

Order 13-3406. Passing Through Walls.

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

Order 13-3407. Protection.

Where exposed to mechanical injury the cable shall be protected.

Order 13-3408. Boxes and Fittings.

Boxes and fittings shall conform to the following:

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

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

Order 13-3409. Grounding.

Metal boxes, fittings, or cabinets if used shall be grounded in accordance with Section 13-250.

SECTION 13-342. NON-METALLIC SURFACE EXTENSIONS

Order 13-3421. Scope.

Installations of non-metallic surface extensions shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and in addition shall comply with the provisions of the following Orders 13-3422 to 13-3429, inclusive.

Order 13-3422. Use.

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

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

B. The extensions are run exposed in dry locations.

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

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

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

F. The extensions are not subject to corrosive vapors.

Order 13-3423. Outlets Per Circuit.

The total number of outlets supplied by one branch circuit, including those previously installed and those of the extension, shall be in conformity with the requirements of Section 13-210.

Order 13-3424. Not to Run Outside Room.

An extension shall not be run through a floor or partition, nor outside the room in which it originates.

Order 13-3425. Location in Room.

One or more extensions may be run in any direction from an existing outlet, but not on the floor or within 2 inches from the floor. An extension shall be attached only to woodwork or plaster finish, and shall not be in contact with any metal work or other conductive material except the metal plates on receptacles.

Order 13-3426. Supports.

Non-metallic surface extensions shall be secured in place by approved means at intervals not exceeding 8 inches, except that where connection to the supplying outlet is made by means of an attachment plug the first fastening may be placed 12 inches or less from the plug. There shall be at least one fastening between each two adjacent outlets supplied.

Order 13-3427. Splices and Taps.

Extensions shall consist of a continuous unbroken length of the assembly, without splices, and without exposed conductors between fittings. Taps may be made if fittings completely covering the tap connections are used.

Order 13-3428. Bends.

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

Order 13-3429. Fittings.

Each run of an assembly shall terminate in a fitting which covers the end of the assembly. All fittings and devices shall be of a type approved for the purpose.

SECTION 13-344. UNDERPLASTER EXTENSIONS

Order 13-3441. Use.

Underplaster extensions, installed as permitted by Orders 13-3441 to 13-3444, inclusive, may be used only for extensions of existing branch circuits, if laid on the face of masonry or other material and buried in the plaster finish of ceilings or walls, in buildings of fire-resistive construction.

Order 13-3442. Materials.

Such extensions shall be run in rigid or flexible conduit, armored cable, electrical metallic tubing or metal raceways approved for the purpose. Standard sizes of conduit, cable, tubing and raceways shall be used except that for single conductors only, conduit or tubing having not less than $\frac{5}{16}$ inch inside diameter or single-conductor armored cable may be used.

Order 13-3443. Limit of Run.

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

Order 13-3444. Methods of Installation.

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

SECTION 13-346. RIGID METAL CONDUIT

Order 13-3461. Scope.

Installations of rigid metal conduit shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and in addition shall comply with the provisions of the following Orders 13-3462 to 13-3471, inclusive.

Order 13-3462. Use.

Rigid metal conduit may be used under all atmospheric conditions and occupancies, except that ferrous raceways and fittings protected from corrosion solely by enamel may be used only indoors and in occupancies not subject to severe corrosive influences. Conduits and fittings exposed to severe corrosive influences shall be of corrosion-resistant material suitable for the conditions. If practicable, the use of dissimilar metals throughout the system shall be avoided to eliminate the possibility of galvanic action.

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

Order 13-3463. Cinder Fill.

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

Order 13-3464. Wet Locations.

In portions of dairies, laundries, canneries, and other wet locations, and in locations where walls are frequently washed, the entire conduit system, including all boxes and fittings used therewith, shall be so installed and equipped as to prevent water from entering the conduit and the conduit shall be mounted so that there is at least one-quarter inch air space between the conduit and the wall or other supporting surface.

Order 13-3465. Minimum Size.

No conduit smaller than ½ inch, electrical trade size, shall be used, except as provided for under-plaster extensions in Section 13-344, and for enclosing the leads of motors as permitted in Order 13-4439.

Order 13-3466. Number of Conductors in Raceway.

One conduit shall not contain more conductors of a given size than are specified in Tables 4 to 11 of Chapter 10.

Order 13-3467. Reaming.

All ends of conduit shall be reamed to remove rough edges.

Order 13-3468. Bushings.

Where a conduit enters a box or other fitting, a bushing shall be provided to protect the wire from abrasion unless the design of the box or fitting is such as to afford equivalent protection. See paragraph B of Order 13-3736 for the protection of conductors at bushings.

Order 13-3469. Couplings.

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

Order 13-3470. Bends—How Made.

Bends of rigid conduit shall be so made that the conduit will not be injured, and that the internal diameter of the conduit will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in the following table:

Radius of Conduit Bends

Size of Conduit	Conductors Without Lead Sheath	Conductors With Lead Sheath
½ in.	3.7 in.	6.2 in.
¾ in.	4.9 in.	8.3 in.
1 in.	6.3 in.	10.5 in.
1¼ in.	8.3 in.	13.8 in.
1½ in.	9.6 in.	16.1 in.
2 in.	12.4 in.	20.6 in.
2½ in.	14.8 in.	24.6 in.
3 in.	18.4 in.	30.6 in.
3½ in.	21.3 in.	35.5 in.
4 in.	24.1 in.	40.2 in.
4½ in.	27.0 in.	45.0 in.
5 in.	30.3 in.	50.4 in.
6 in.	36.4 in.	60.6 in.

Order 13-3471. Bends—Number in One Run.

A run of conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting shall not contain more than the equivalent of 4 quarter bends (360° total), including those bends located immediately at the outlet or fitting.

SECTION 13-348. ELECTRICAL METALLIC TUBING

Order 13-3481. Scope.

Installations of electrical metallic tubing shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and in addition shall comply with the provisions of the following Orders 13-3482 to 13-3490 inclusive.

Order 13-3482. Use.

Electrical metallic tubing may be used for both exposed and concealed work. Electrical metallic tubing protected from corrosion solely by enamel shall not be used. Electrical metallic tubing shall not be used (1) where during installation or afterwards, it will be subject to severe mechanical injury; (2) in cinder concrete or fill where subject to permanent moisture unless protected on all sides by a layer of non-cinder concrete at least 2 inches thick or unless the tubing is at least 18 inches under the fill; (3) in any hazardous locations except as otherwise provided in Section 13-500; (4) where exposed to corrosive vapor except as permitted in Order 13-3483.

Order 13-3483. Corrosive Fumes.

If tubing is exposed to corrosive fumes or vapors such as may exist in meat packing plants, tanneries, hide cellars, casing rooms, glue houses, fertilizer rooms, salt storage, some chemical works, metal refineries, pulp mills, sugar mills, round houses, some stables, and similar locations, tubing and fittings of corrosion-resistant material suitable for the conditions shall be used. If practicable, the use of dissimilar metals throughout the system shall be avoided to eliminate the possibility of galvanic action.

Order 13-3484. Wet Locations.

In portions of dairies, laundries, canneries, and other wet locations, and in locations where walls are frequently washed, the entire tubing system, including all boxes and fittings used therewith, shall be so installed and equipped as to prevent water from entering the tubing, and the tubing shall be mounted so that there is at least one-quarter inch air space between the tubing and the wall or other supporting surface.

Order 13-3485. Minimum and Maximum Sizes.

No tubing smaller than ½ inch, electrical trade size, shall be used except as provided for underplaster extensions in Section 13-344 and for enclosing the leads of motors as permitted in paragraph B of

Order 13–4439. The maximum size of tubing shall be the 2-inch electrical trade size.

Order 13–3486. Number of Conductors in Raceway.

One tubing shall not contain more conductors of a given size than are specified in Tables 4 to 11 of Chapter 10.

Order 13–3487. Threads.

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

Order 13–3488. Couplings and Connectors.

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

Order 13–3489. Bends—How Made.

Bends in the tubing shall be so made that the tubing will not be injured and that the internal diameter of the tubing will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in the table in Order 13–3470.

Order 13–3490. Bends—Number in One Run.

A run of electrical metallic tubing between outlet and outlet, between fitting and fitting, or between outlet and fitting, shall not contain more than the equivalent of four quarter bends (360° total), including those bends located immediately at the outlet or fitting.

SECTION 13–350. FLEXIBLE METAL CONDUIT

Order 13–3501. Scope.

Installations of flexible metal conduit shall comply with the provisions of Orders 13–3001 to 13–3020, Orders 13–3343, 13–3344, 13–3346, and Orders 13–3465 to 13–3468, inclusive, and in addition shall comply with the provisions of the following Orders 13–3502 and 13–3503.

Order 13–3502. Use.

Flexible metal conduit shall not be used (1) in wet locations, unless conductors are of the lead covered type or of other type specially approved for the conditions; (2) in hoistways, except as provided in Order 13–6206; (3) in storage battery rooms; (4) in any hazardous location except as permitted by Orders 13–5054 and 13–5073; nor (5) where rubber covered conductors are exposed to oil, gasoline, or other materials having a deteriorating effect on rubber.

Order 13–3503. Minimum Size.

No flexible metal conduit less than one-half inch electrical trade size shall be used except (1) as permitted for underplaster extensions by Order 13–3442; (2) as permitted for motors by paragraph B of Order 13–4439; and (3) for connection not over 48 inches in length, or longer on approved assemblies, to equipment where the use of one-half inch or larger size flexible metal conduit is not practicable in which case flexible metal conduit of three-eighth inch electrical trade size may be used.

SECTION 13–351—LIQUID-TIGHT FLEXIBLE METAL CONDUIT

Order 13–3511. Scope.

Liquid-tight flexible metal conduit is not intended as a general purpose raceway material. The provisions of this section shall apply to a type of flexible conduit having an outer liquid-tight jacket and employed with suitable terminal fittings approved for the purpose.

Order 13–3512. Use.

The use of this wiring material shall be restricted as follows:

A. For the connection of motors or portable equipment where flexibility of connection is required.

B. Liquid-tight flexible metal conduit shall not be used under the following conditions: (1) Where subject to mechanical injury; (2) Where in contact with rapidly moving parts; (3) Under conditions such that its temperature, with or without enclosed conductors carrying current, is above 60 C (140F); (4) In any hazardous location, except as described in 13–5014–B, 13–5054, and 13–5073 of Section 13–500, unless it is specially approved for such use.

Order 13–3514. Maximum Size.

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

Order 13–3515. Conductor Size.

The maximum size of conductor installed in liquid-tight flexible metal conduit shall not exceed the following values:

Trade Size of Conduit	Size of Conductor
⅜ inch	16 AWG
½ inch	12 AWG
¾ inch	8 AWG
1 inch	6 AWG
1¼ inch	2 AWG

SECTION 13–352. SURFACE METAL RACEWAY

Order 13–3521. Scope.

Installations of surface metal raceways shall comply with the provisions of Orders 13–3001 to 13–3020, inclusive, and in addition shall comply with the provisions of the following Orders 13–3522 to 13–3527, inclusive.

Order 13-3522. Use.

Surface metal raceway may be used in dry locations. It shall not be used (1) where concealed, except that the back and sides of multi-outlet assembly may be surrounded by the building finish; and metal raceways approved for the purpose may be used for under-plaster extensions; (2) where subject to severe mechanical injury unless approved for the purpose; (3) where the voltage is 300 volts or more between conductors unless the metal has a thickness of not less than .040 inches; (4) where subject to corrosive vapors; (5) in hoistways; (6) in storage battery rooms; nor (7) in any hazardous location.

Order 13-3523. Size of Conductors.

No conductor larger than No. 6 shall be installed in surface metal raceway.

Order 13-3524. Number of Conductors in Raceway.

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

Order 13-3525. Extension Through Walls and Floors.

Except in multi-outlet assemblies, raceways may be extended through dry walls, dry partitions and dry floors, if in unbroken lengths where passing through.

Order 13-3526. Combination Raceways.

If combination metal raceways are used both for signal and for lighting and power circuits, the different systems shall be run in separate compartments, identified by sharply contrasting colors of the interior finish, and the same relative position of compartments shall be maintained throughout the premises.

Order 13-3527. Multi-Outlet Assembly.

Multi-outlet assembly, and all fittings used in connection with the assembly, shall be approved for the purpose.

SECTION 13-354. UNDERFLOOR RACEWAY

Order 13-3541. Scope.

Installations of underfloor raceways shall comply with the provisions of Orders 13-3001 to 13-3020, inclusive, and in addition shall comply with the provisions of the following Orders 13-3542 to 13-3556, inclusive.

Order 13-3542. Use.

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

Order 13-3543. Covering.

Raceway coverings shall conform to the following:

A. *Raceways Not Over 4 Inches Wide.* Half-round raceways not over 4 inches in width, and, except as permitted in paragraph C of this order, flat-top raceways not over 4 inches in width, shall have not less than ¾ inches of concrete or wood above the raceway.

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

C. *Raceways Flush With Concrete.* Approved metal flat-top raceways if not over 4 inches in width may, in office occupancies, be laid flush with the concrete floor surface if covered with substantial linoleum not less than ⅛ inch in thickness or with equivalent floor covering. When more than one and not more than three single raceways are each installed flush with the concrete, they must be (1) contiguous with each other and joined to form a rigid assembly, or (2) spaced not less than ½ inch apart.

Order 13-3544. Size of Conductors.

No conductor larger than that for which the raceway is approved shall be installed in underfloor raceways and the largest size conductor allowed shall be No. 0 AWG.

Order 13-3545. Number of Conductors in Raceway.

The combined cross-sectional area of all conductors shall not exceed 40 per cent of the interior area of the raceway; except that if the raceway contains only armored cable or non-metallic sheathed cable, these requirements shall not apply.

Order 13-3546. Splices and Taps.

Splices or taps shall be made only in junction boxes.

Order 13-3547. Discontinued Outlets.

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

Order 13-3548. Open-Bottom Raceway—How Laid.

Open-bottom raceway shall be laid on a smooth pad of concrete extending at least 1 inch on each side of the raceway and at least 1 inch thick, except that this thickness may be reduced to ¼ inch where the raceway crosses a run of conduit, and except that in lieu of a concrete pad, fittings which will protect the conductors from contact with piping, structural steel and other obstructions may be used. Raceways shall be mechanically secured to the concrete pad.

Order 13–3549. Laid in Straight Lines.

Underfloor raceways shall be laid so that a straight line from the center of one junction box to the center of the next junction box will coincide with the center line of the raceway system. Raceways shall be made mechanically secure to prevent disturbing this alignment during construction.

Order 13–3550. Markers at Ends.

At every end of line of raceway, a fitting shall be installed extending through the floor to mark the line of the duct. Where a duct line is interrupted by another duct line, but continues in a straight line beyond, and has junction boxes or outlets on either side of the crossing line, no markers are necessary at the interrupting point.

Order 13–3551. Dead Ends.

Dead ends of raceways shall be closed.

Order 13–3552. Low Points.

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

Order 13–3553. Special Fittings at Angles.

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

Order 13–3554. Junction Boxes.

Junction boxes shall be leveled to the floor grade and sealed against the entrance of water. Junction boxes used with metal raceways shall be metal and shall be electrically continuous with the raceways.

Order 13–3555. Inserts.

Inserts shall be leveled to the floor grade and sealed against the entrance of water. Inserts used with metal raceways shall be metal and shall be electrically continuous with the raceway. Inserts set in or on fiber raceways before the floor is laid shall be mechanically secured to the raceway. Inserts set in fiber raceways after the floor is laid shall be screwed into the raceway. In cutting through the raceway wall and setting inserts, chips and other dirt shall not be allowed to fall into the raceway, and tools shall be used which are so designed as to prevent the tool from entering the raceway and injuring conductors that may be in place.

Order 13–3556. Connections to Cabinets and Wall Outlets.

Connections between raceways and distribution centers and wall outlets shall be made by means of rigid or flexible metal conduit or by means of fittings specially approved for the purpose.

SECTION 13–356. CELLULAR METAL FLOOR RACEWAYS

Order 13–3561. Scope.

Installations of cellular metal floor raceways shall comply with the provisions of Orders 13–3001 to 13–3020, inclusive, and in addition shall comply with the provisions of the following Orders 13–3562 to 13–3570. For the purposes of this section a "cellular metal floor raceway" shall be defined as the hollow spaces of cellular metal floors, together with suitable fittings, which may be approved as enclosures for electrical conductors; a "cell" shall be defined as a single, enclosed tubular space in a cellular metal floor member, the axis of the cell being parallel to the axis of the metal floor member; a "header" shall be defined as a transverse raceway for electrical conductors, providing access to predetermined cells of a cellular metal floor, thereby permitting the installation of electrical conductors from a distribution center to the cells.

Order 13–3562. Use.

Conductors shall not be installed in cellular metal floor raceways (1) where subject to corrosive vapor; (2) in any hazardous location; (3) in commercial garages, except for supplying ceiling outlets or extensions to the area below the floor but not above; nor (4) in storage battery rooms. No electric conductors shall be installed in any cell or header which contains a pipe for steam, water, air, gas, drainage, or other service than electrical.

Order 13–3563. Size of Conductors.

No conductor larger than No. 0 shall be installed, except by special permission.

Order 13–3564. Number of Conductors in Raceway.

The combined cross-sectional area of all conductors shall not exceed 40 per cent of the interior area of the header feeding the individual cells; except that if the raceway contains only armored cable or nonmetallic sheathed cable, these requirements shall not apply.

Order 13–3565. Splices and Taps.

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

Order 13–3566. Discontinued Outlets.

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

Order 13–3567. Markers.

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

Order 13–3568. Junction Boxes.

Junction boxes shall be leveled to the floor grade and sealed against the entrance of water. Junction boxes used with these raceways shall be of metal and shall be electrically continuous with the raceway.

Order 13–3569. Inserts.

Inserts shall be levelled to the floor grade and sealed against the entrance of water. Inserts shall be of metal and shall be electrically continuous with the raceway. In cutting through the cell wall and setting inserts, chips and other dirt shall not be allowed to fall into the raceway, and tools shall be used which are designed to prevent the tool from entering the cell and injuring the conductors.

Order 13–3570. Connection to Cabinets and Extensions from Cells.

Connections to cabinets and extensions from cells to outlets shall be made by means of rigid or flexible conduit or by means of fittings approved for the purpose.

SECTION 13–362. WIREWAYS

Order 13–3621. Scope.

Installations of wireways shall comply with the provisions of Orders 13–3001 to 13–3020, inclusive, and in addition shall comply with the provisions of the following Orders 13–3622 to 13–3630, inclusive.

Order 13–3622. Use.

Wireways may be used only for exposed work in dry locations in industrial occupancies, garages and theaters, including motion-picture houses. Wireways shall not be used (1) where subject to severe mechanical injury or corrosive vapor; (2) in hoistways; (3) in any hazardous location; nor (4) in storage-battery rooms.

Order 13–3623. Size of Conductors.

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

Order 13–3624. Number of Conductors in Raceway.

Wireways shall not contain more than 30 conductors at any cross section, unless the conductors are for signaling circuits or are control conductors between a motor and its starter and used only for starting duty. The sum of the cross-sectional areas of all contained conductors at any cross section of a wireway shall not exceed 20 per cent of the interior cross-sectional area of the wireway.

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

Order 13–3625. Splices and Taps.

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

Order 13–3626. Supports.

Wireways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet.

Order 13–3627. Extension Through Walls.

Wireways may extend transversely through dry walls if in unbroken lengths where passing through.

Order 13–3628. Dead-Ends.

Dead-ends of wireways shall be closed.

Order 13–3629. Extensions from Wireways.

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

Order 13–3630. Marking.

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

SECTION 13–364. BUSWAYS.

Order 13–3641. Scope.

Installations of busways shall comply with the provisions of Orders 13–3001 to 13–3020, inclusive, and in addition shall comply with the provisions of the following Orders 13–3642 to 13–3653, inclusive.

Order 13–3642. Use.

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

Busways may be used for service-entrance conductors. See Order 13–2331.

Order 13–3643. Support.

Busways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet. If a busway is installed in a vertical position, the supports for the busbars shall be designed for vertical installation.

Order 13–3644. Extension Through Walls.

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

Order 13–3645. Dead-Ends.

Dead-ends of busways shall be closed.

Order 13–3646. Branches from Busways.

Branches from busways shall be made with busways or with rigid or flexible metal conduit, electrical metallic tubing, surface metal race-

way, armored cable or, for portable appliances, with suitable cord assemblies approved for hard usage.

Order 13–3647. Overcurrent Protection.

Overcurrent protection shall be provided in accordance with Orders 13–3648 to 13–3652 inclusive.

Order 13–3648. Rating of Overcurrent Protection—Feeders and Subfeeders.

If the allowable current rating of the busway does not correspond to a standard rating of the overcurrent device, the next higher rating may be used, but not exceeding 150 per cent of the allowable current rating of the busway.

Order 13–3649. Reduction in Size of Busway.

Overcurrent protection may be omitted at points where busways are reduced in size, provided that the smaller busway does not extend more than 50 feet and has a current rating at least equal to one-third the rating or setting of the overcurrent device next back on the line, and provided further that such busway is free from contact with combustible material.

Order 13–3650. Branch Circuits.

Where a busway is used as a feeder, devices or plug-in connections for tapping off branch circuits from the busway shall contain the overcurrent devices required for the protection of the branch circuits, except as permitted in Order 13–2434. Where the overcurrent device is not readily accessible, it shall be enclosed or guarded until it is electrically disconnected from the busway.

Order 13–3651. Rating of Overcurrent Protection—Branch Circuits.

A busway may be used as a branch circuit of any one of the types described in Section 13–210. 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 Section 13–210 applying to branch circuits of that rating.

Order 13–3652. Length of Busways Used as Branch Circuits.

Busways which are used as branch circuits and which are so designed that loads can be connected at any point shall be limited to such lengths as will provide that in normal use the circuits will not be overloaded. In general, the length of such run in feet should not exceed three times the ampere rating of the branch circuit.

Order 13–3653. Marking.

Busways shall be marked with the voltage and current rating for which they are designed, and with the manufacturer's name or trademark in such manner as to be visible after installation.

It is recommended that where secondary systems are operated ungrounded, a combination ground detector and potentializer plug be used as an auxiliary fitting for busway systems to establish a definite potential difference between the bus-bars and the grounded casing of the busways. This will serve to drain off any static or other charge from the entire busway system including its connected apparatus, supply and branch circuit conductors.

SECTION 13–370. OUTLET, SWITCH AND JUNCTION BOXES, AND FITTINGS

Order 13–3701. Scope.

The provisions of this section shall apply to the installation of outlet, switch and junction boxes, and fittings as required by Order 13–3007. Installations in hazardous locations shall conform to Section 13–500.

Order 13–3702. Use of Round Outlet Boxes.

Round outlet boxes shall not be used where conduits or connectors requiring the use of locknuts or bushings are to be connected to the side of the box.

Order 13–3703. Non-Metallic Outlet Boxes.

Non-metallic outlet boxes may be used only with open wiring on insulators, concealed knob-and-tube work, non-metallic sheathed cable, and with non-metallic waterproof wiring.

Order 13–3704. Metallic Outlet Boxes.

When used with knob-and-tube work or non-metallic sheathed cable, and mounted on metal or metal lath ceilings or walls, such boxes shall be insulated from their supports and from the metal or metal lath, or shall be grounded.

Order 13–3705. Damp or Wet Locations.

In damp or wet locations, boxes and fittings shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the box or fitting. Boxes and fittings installed in wet locations shall be weatherproof. For boxes in floors, see Order 13–4162.

It is recommended that boxes of non-conductive material be used with non-metallic sheathed cable when such cable is used in locations where there is likely to be occasional moisture present such as in dairy barns.

Order 13–3706. Depth of Boxes for Concealed Work.

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

Order 13–3707. Supports—General.

Boxes, fittings and cabinets shall be securely fastened in place. Boxes and fittings, not over 100 cubic inches in size, which are attached

to firmly secured exposed raceway by threading or other connection designed for the purpose, are considered as so fastened.

A. *Concealed Work.* In concealed work, except as prescribed in paragraph B of this order, outlet boxes and fittings, unless securely held in place by concrete, masonry or other building material in which they are embedded, shall be secured to a stud, joist or similar fixed structural unit, or to a metal or wooden support which is secured to such a structural unit. Where there are gang boxes, additional support shall be provided. Wooden supports shall be not less than ⅞ inch in thickness. Lath of wood, metal or composition shall not be considered a structural unit. See Orders 13-4131 and 13-4132 for support of fixtures.

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

Order 13-3708. Pull and Junction Boxes.

Pull and junction boxes shall conform to the following:

A. *Minimum Size.* For raceways of 1¼ inch trade size and larger, containing conductors of No. 6 or larger, the minimum dimensions of a pull box or a junction box installed in a raceway shall conform to the following:

1. Straight Pulls. In straight pulls the length of the box shall be not less than 8 times the trade diameter of the largest raceway.

2. Angle or U Pulls. Where angle or U pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than 6 times the trade diameter of the raceway. This distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than 6 times the trade diameter of the larger raceway.

3. Exceptions. The limitations of sub-paragraphs 1 and 2 of this order are not intended to apply to terminal housings supplied with motors, nor to types of boxes or fittings without knockouts and having hubs or recessed ports for terminal bushings and locknuts.

B. *Conductors in Pull or Junction Boxes.* In pull boxes or junction boxes having any dimension over 6 feet, all conductors shall be cabled or racked up in an approved manner.

See Order 13-3736 for insulation of conductors at bushings.

Order 13-3709. Number of Conductors in a Box.

Boxes shall be of sufficient size to provide free space for all conductors enclosed in the box.

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

Deep Boxes

Box Dimensions Trade Size	Maximum Number of Conductors No. 14	No. 12	No. 10	No. 8
1½ x 3¼ octagonal	5	5	4	0
1½ x 4 octagonal	8	7	6	5
1½ x 4 square	11	9	7	5
1½ x 4 11/16 square	16	12	10	8
2⅛ x 4 11/16 square	20	16	12	10
2 x 1¾ x 2¾	5	4	4	
2½ x 1¾ x 2¾	6	6	5	
3 x 1¾ x 2¾	7	7	6	

Shallow Boxes of Less Than 1½" Depth

Box Dimensions Trade Size	Maximum Number of Conductors No. 14	No. 12	No. 10
3¼	4	4	3
4	6	6	4
4 11/16	8	6	6

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

B. For combinations not shown in above tables the following table shall apply:

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

C. The limitations in paragraphs A and B of this order shall not apply to terminal housings supplied with motors, nor to types of boxes or fittings without knockout and having hubs or recessed parts for terminal bushings and locknuts.

Paragraphs A and B of Order 13-3709 do not apply to conductors used for rewiring existing raceways as referred to in Table 11, Chapter 10.

Order 13-3710. Conductors Entering Boxes or Fittings.

Conductors entering boxes or fittings shall be protected from abrasion, and shall conform to the following:

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

B. *Metal Boxes and Fittings.* If metal outlet boxes or fittings are used with open wiring or concealed knob-and-tube work, conductors

shall enter through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the box or fitting. Where raceway or cable is used with metal outlet boxes or fittings, the raceway or cable shall be secured to such boxes and fittings.

C. *Non-Metallic Boxes.* If non-metallic boxes are used with open wiring or concealed knob-and-tube work, the conductors shall enter through individual holes. Where flexible tubing is used to encase the conductor, the tubing shall extend from the last insulating support and may be run into the box or terminate at the wall of the box. If non-metallic sheathed cable is used, the cable assembly shall enter the box through a knockout opening. Clamping of individual conductors or cables to the box is not required if supported within 8 inches of the box.

Order 13-3711. Covers and Canopies.

In completed installations each outlet box shall be provided with a cover unless a fixture canopy is used.

A. Non-metallic covers and plates shall be used with non-metallic outlet boxes.

B. If a fixture canopy or pan is used, any combustible wall or ceiling finish exposed between the edge of the canopy or pan and the outlet box shall be covered with non-combustible material.

C. Covers of outlet boxes having holes through which flexible cord pendants pass, shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear. So-called hard-rubber or composition bushings shall not be used.

Order 13-3712. Unused Openings.

Unused openings in boxes, fittings and cabinets shall be effectively closed to afford protection substantially equivalent to that of the wall of the box or fitting. Metal plugs or plates shall not be used with non-metallic boxes or fittings unless recessed at least ¼ inch from the outer surface.

Order 13-3713. Boxes Enclosing Flush Devices.

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

Order 13-3714. Fastened to Gas Pipes.

Outlet boxes used where gas outlets are present shall be so fastened to the gas pipes as to be mechanically secure.

Order 13-3715. Position in Wall.

In walls or ceilings of concrete, tile or other non-combustible material, boxes and fittings shall be so installed that the front edge of the box or fitting will not set back of the finished surface more than ¼ 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.

Order 13-3716. Repairing Plaster.

Except on walls or ceilings of concrete, tile or other non-combustible material, a plaster surface which is broken or incomplete shall be repaired so that there will be no gaps or open spaces at the edge of the box or fitting.

Order 13-3717. Junction Boxes to Be Accessible.

Junction boxes shall be so installed that the wiring contained in them may be rendered accessible without removing any part of the building. In finished rooms, wiring and splices in a junction or outlet box having a blank cover, and not more than 6 inches back of the finished wall or ceiling surface, shall be considered accessible when one or more suitable markers extend through the plaster, paint or other finish for future location and identification of the box.

Order 13-3718. Exposed Extensions.

In making an exposed extension from an existing outlet of concealed wiring, a box, extension ring or blank cover shall be mounted over the original box and electrically and mechanically secured to it. The extension shall then be connected to this box in the manner prescribed for the method of wiring employed in making the extension.

Order 13-3719. Boxes at Fixture Outlets.

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

SECTION 13-373. CABINETS AND CUTOUT BOXES

Order 13-3731. Scope.

The provisions of this section shall apply to the installation of cabinets and cutout boxes. Installations in hazardous locations shall conform to the provisions of Section 13-500.

Order 13-3732. Damp or Wet Locations.

In damp or wet locations, cabinets and cutout boxes of the surface type shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the cabinet or cutout box, and shall be mounted so there is at least one-quarter inch air space between the enclosure and the wall or other supporting surface. Cabinets or cutout boxes installed in wet locations shall be weatherproof.

It is recommended that boxes of non-conductive material be used with non-metallic sheathed cable when such cable is used in locations where there is likely to be moisture present.

Order 13-3733. Position in Wall.

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

Order 13-3734. Unused Openings.

Unused openings in cabinets or cutout boxes shall be effectively closed to afford protection substantially equivalent to that of the wall of the cabinet or cutout box. If metal plugs or plates are used with non-metallic cabinets or cutout boxes, they shall be recessed at least ¼ inch from the outer surface.

Order 13-3735. Conductors Entering Cabinets or Cutout Boxes.

Conductors entering cabinets or cutout boxes shall be protected from abrasion and shall conform to the following:

A. *Openings to Be Closed.* Openings through which conductors enter shall be adequately closed.

B. *Metal Cabinets and Cutout Boxes.* If metal cabinets or cutout boxes are used with open wiring or concealed knob-and-tube work, conductors shall enter through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the cabinet or cutout box.

Order 13-3736. Deflection of Conductors.

Conductors entering or leaving cabinets or cutout boxes and the like shall conform to the following:

A. *Width of Gutters.* Vertical conductors No. 1 or larger shall not be deflected where they enter or leave a cabinet unless a gutter having a width in accordance with the following table is provided:

Conductor Size	Minimum Width of Gutter in Inches
No. 1	3
No. 0 to 200,000 c.m.	4
211,600 to 500,000 c.m.	6
600,000 to 900,000 c.m.	8
1,000,000 to 1,400,000 c.m.	10
1,500,000 to 2,000,000 c.m.	12

B. *Insulation at Bushings.* Where ungrounded conductors of No. 4 or larger enter a raceway in a cabinet, pull box, junction box, or auxiliary gutter, the conductors shall be protected by a substantial bushing providing a smoothly rounded insulating surface, unless the conductors are separated from the raceway fitting by substantial insulating material securely fastened in place. If conduit bushings are constructed wholly of insulating material, a locknut shall be provided both inside and outside the enclosure to which the conduit is attached.

Order 13-3737. Space in Enclosures.

Cabinets and cutout boxes shall conform to the following:

A. *To Accommodate Conductors.* Cabinets and cutout boxes shall be selected which have sufficient space to accommodate all conductors installed in them without crowding.

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

Order 13-3738. Side or Back Wiring Spaces or Gutters.

Cabinets and cutout boxes shall be provided with back wiring spaces, gutters or wiring compartments as required by sub-paragraphs C and D of Order 13-93732.

SECTION 13-374. AUXILIARY GUTTERS

Order 13-3741. Purpose.

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

Order 13-3742. Extension Beyond Equipment.

An auxiliary gutter shall not extend a greater distance than 30 feet beyond the equipment which it supplements except in elevator work. Any extension beyond this distance shall comply with the provisions for wireways in Section 13-362 or with the provisions for busways in Section 13-364.

Order 13-3743. Supports.

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

Order 13-3744. Covers.

Covers shall be securely fastened to the gutter.

Order 13-3745. Number of Conductors in Raceway.

Auxiliary gutters shall not contain more than 30 conductors at any cross section unless the conductors are for signalling circuits or are control conductors between a motor and its starter and used only for starting duty. The sum of the cross sectional areas of all contained conductors at any cross section of an auxiliary gutter shall not exceed 20 per cent of the interior cross sectional area of the gutter.

For elevators see order 13-6215.

Order 13-3746. Carrying Capacity of Copper Bars.

The current carried continuously in bare conductors in auxiliary gutters shall not exceed 1000 amperes per square inch of cross section of the conductor.

Order 13-3747. Clearance of Bare Live Parts.

Bare conductors shall be securely and rigidly supported so that the minimum clearance between bare current carrying metal parts of opposite polarities mounted on the same surface shall be not less than 2 inches, nor less than 1 inch for parts that are held free in the air. A spacing not less than 1 inch shall be secured between bare current carrying metal parts and any metal surface. Adequate provision shall be made for expansion and contraction of copper bars.

Order 13-3748. Splices and Taps.

Splices and taps shall conform to the following:

A. Splices or taps, made and insulated by approved methods, may be located within gutters if they are accessible by means of removable covers or doors. The conductors, including splices and taps, shall not fill the gutter to more than 75 per cent of its area.

B. Taps from bare conductors shall leave the gutter opposite their terminal connections and conductors shall not be brought in contact with uninsulated current carrying parts of opposite polarity.

C. All taps shall be suitably identified at the gutter as to the circuit or equipment which they supply.

D. Tap connections from conductors in auxiliary gutters shall be provided with overcurrent protection in conformity with the provisions of Order 13-2484.

Order 13-3749. Construction.

Auxiliary gutters shall be constructed in accordance with the following:

A. Gutters shall be so constructed and installed that adequate electrical and mechanical continuity of the complete raceway system will be secured.

B. Gutters shall be of substantial construction and shall provide a complete enclosure for the contained conductors. All surfaces, both interior and exterior, shall be suitably protected from corrosion. Corner joints shall be made tight and where the assembly is held together by rivets or bolts, these shall be spaced not more than 12 inches apart.

C. Suitable bushings, shields or fittings having smooth rounded edges shall be provided where conductors pass between gutters, through partitions, around bends, between gutters and cabinets or junction boxes and at other locations where necessary to prevent abrasion of the insulation of the conductors.

D. Gutters shall be constructed of sheet metal of thicknesses not less than in the following table:

Maximum Width of the Widest Surface of Gutters	Thickness (USS Sheet Steel Gauge)	
Up to and including 6 inches	No. 16	.0598 inch
Over 6 in. and not over 18 in.	No. 14	.0747 inch
Over 18 in. and not over 30 in.	No. 12	.1046 inch
Over 30 inches	No. 10	.1345 inch

E. Where insulated conductors are deflected within the auxiliary gutter, either at the ends or where conduits, fittings or other raceways enter or leave the gutter, or where the direction of the gutter is deflected greater than 30 degrees, dimensions corresponding to Order 13-3736 shall apply.

SECTION 13-380. SWITCHES

Order 13-3801. Grounded Conductors.

No switch or circuit-breaker shall disconnect the grounded conductor of a circuit unless the switch or circuit-breaker simultaneously disconnects the ungrounded conductor or conductors, or unless the switch or circuit-breaker is so arranged that the grounded conductor cannot be disconnected until the ungrounded conductor or conductors have first been disconnected.

Order 13-3802. Three-Way and Four-Way Switches

Three-way and four-way switches shall be so wired that all switching is done only in the ungrounded circuit conductor. Wiring between switches and outlets shall, if in metal enclosures, be run with both polarities in the same enclosure.

Order 13-3803. Enclosures.

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

Order 13-3804. Wet Locations.

If a switch or circuit-breaker is in a wet location or outside of a building, it shall be enclosed in a weatherproof enclosure or cabinet installed to conform to Order 13-3732.

Order 13-3805. Time Switches, Flashers and Similar Devices.

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

Order 13-3806. Position of Knife Switches.

Single-throw knife switches shall be so placed that gravity will not tend to close them. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal as preferred, but if the throw be vertical a locking device shall be provided which will insure the blades remaining in the open position when so set.

Order 13-3807. Connection of Knife Switches.

Knife switches, unless of the double-throw type, shall be so connected that the blades are dead when the switch is in the open position.

Order 13–3808. Accessibility and Grouping.

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

Order 13–3809. Covers of Flush Snap Switches.

Flush snap switches, if mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces, shall be provided with covers of non-conducting, non-combustible material. Face plates, if of metal, shall be not less than 0.04 inch in thickness, and plates of non-conducting, non-combustible material shall be not less than 0.10 inch in thickness.

Order 13–3810. Mounting of Surface Type Snap Switches.

Snap switches used with open wiring on insulators shall be mounted on sub-bases of insulating material which will separate the conductors at least ½ inch from the surface wired over.

Order 13–3811. Circuit-Breakers as Switches.

A circuit-breaker operable directly by applying the hand to a lever or handle may serve as a switch provided it has the number of poles required for such switch.

Order 13–3812. Grounding of Enclosures.

Enclosures for switches or circuit-breakers on circuits of over 150 volts to ground shall be grounded in the manner specified in Section 13–250, except where accessible to qualified operators only.

Order 13–3813. Knife Switches.

Knife switches rated for more than 1200 amperes at 250 volts or less, and for more than 600 amperes at 251 to 600 volts, shall be used only as isolating switches and shall not be opened under load. To interrupt currents greater than 1200 amperes at 250 volts or less, or 600 amperes at 251 to 600 volts, a circuit-breaker or a switch of special design approved for such purpose shall be used. Knife switches of lower rating may be used as general use switches and may be opened under load. Motor circuit switches (see definition) may be of the knife switch type.

Order 13–3814. Rating of Snap Switches.

Snap switches shall be rated as follows:

A. *Non-Inductive Loads.* For non-inductive loads other than tungsten-filament lamps, switches shall have an ampere rating not less than the ampere rating of the load.

B. *Tungsten Filament Loads.* For tungsten-filament lamp loads, and for combined tungsten-filament and non-inductive loads, switches shall be "T" rated, except where the three following qualifications are satisfied:

1. If switches are used in branch circuit wiring systems in private homes; in rooms in multiple-occupancy dwellings used only as living quarters by tenants; in private hospital or hotel rooms; or in similar locations but not in public rooms or places of assembly; and

2. Only when such a switch controls permanently connected fixtures or lighting outlets in one room only, or in one continuous hallway where the lighting fixtures may be located at different levels, or on porches or in attics or basements not used for assembly purposes; and

3. When the switch is rated at not less than 10A, 125V; 5A, 250V; or for the 4-way types, 5A, 125V; 2A, 250V.

C. *Inductive Loads.* Switches controlling inductive loads shall have an ampere rating twice the ampere rating of the load unless they are of a type approved as part of an assembly or for the purpose employed.

For switches on signs and outline lighting, see Orders 13–6002, 13–6003 and 13–6004.

For switches controlling motors, see Order 13–4383.

SECTION 13–384. SWITCHBOARDS AND PANELBOARDS

Order 13–3841. Scope.

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

Order 13–3842. Application of Other Sections.

Switches, circuit-breakers and overcurrent devices used on switchboards, panelboards and distribution boards, the boards and their enclosures, shall conform to the requirements of Sections 13–240, 13–370, 13–380 and other sections which apply. Switchboards and panelboards, in hazardous locations shall conform to the requirements of Section 13–500.

Order 13–3843. Support of Bus Bars and Conductors.

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

SWITCHBOARDS

Order 13–3851. Location of Switchboards.

Switchboards which have any exposed live parts shall be located in permanently dry locations and then only where under competent supervision and accessible only to qualified persons.

Order 13–3852. Wet Locations.

If a switchboard is in a wet location or outside of a building, it shall be enclosed in a weatherproof enclosure or cabinet installed to conform to Order 13–3732.

Order 13-3853. Location Relative to Easily Ignitible Material.

Switchboards shall be so placed as to reduce to a minimum the probability of communicating fire to adjacent easily ignitible material.

Order 13-3854. Clearance from Ceiling.

Switchboards shall not be built up to a non-fireproof ceiling, a space of three feet being left between the ceiling and the board, unless an adequate fire-proof shield is provided between the board and the ceiling.

Order 13-3855. Clearance Back of Switchboard.

If the equipment or wiring on the back of the switchboard is accessible only from the space behind the board, there shall be a clear space of at least 18 inches between such equipment or wiring and the wall for a single panel switchboard not exceeding 42 inches in width, and at least 24 inches when the board consists of a wider panel or more than one panel. If the space behind the board is accessible only from one end, these spaces shall be increased by at least 6 inches. The space back of the board shall be kept clear of foreign material and shall not be used for storage purposes.

Reduction of clearances for short intervals by building columns behind the switchboard, or by equipment on a single panel in the switchboard, is permitted provided the clearances are not reduced below those required for a single panel board.

Some of the above dimensions are exceptions to Order 13-1112.

Order 13-3856. Conductor Covering.

Insulated conductors where closely grouped, as on the rear of switchboards, shall each have a flame-retardent outer covering. The conductor covering shall be stripped back a sufficient distance from the terminals so as not to make contact with them. Insulated conductors used for instrument and control wiring on the back of switchboards shall be flame retardant, either inherently or by means of an outer covering, and be one of the following types, R, RH, V, AVA, AVB, T, or TA.

Order 13-3857. Protection of Instrument Circuits.

Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils, except where the operation of the overcurrent device might introduce a hazard in the operation of devices, shall be supplied by a circuit that is protected by standard overcurrent devices of a rating not greater than 15 amperes, except that for ratings of 2 amperes or less special types of enclosed fuses may be used.

Order 13-3858. Grounding—Switchboard Frames.

Switchboard frames and structures supporting switching equipment shall be grounded, except that frames of direct-current single-polarity switchboards need not be grounded if effectively insulated.

Order 13-3859. Grounding of Instruments, Relays, Meters and Instrument Transformers on Switchboards.

Instruments, relays, meters and instrument transformers located on switchboards shall be grounded as specified in Orders 13-2621 to 13-2625.

PANELBOARDS

Order 13-3881. Number of Overcurrent Devices on One Panelboard.

Not more than 42 overcurrent devices of a lighting and appliance branch circuit panelboard shall be installed in any one cabinet or cutout box.

Order 13-3882. Overcurrent Protection.

Except as installed for services as in paragraph A-3 of Order 13-2371, a panelboard supplied by conductors having overcurrent protection greater than 200 amperes shall be protected on the supply side by overcurrent devices having a rating not greater than that of the panelboard. Snap switches rated at 30 amperes or less and employed in panelboards shall have overcurrent protection not in excess of 200 amperes.

Order 13-3883. Panelboards in Damp or Wet Locations.

Panelboards in damp or wet locations shall be installed in conformity to Order 13-3732.

Order 13-3884. Enclosure.

Panelboards shall be mounted in cabinets or cutout boxes.

Order 13-3885. Relative Arrangement of Switches and Fuses.

Panelboards having switches on the load side of any type of fuses shall not be installed except for use as service equipment as provided in Order 13-2375.

SECTION 13-390. PREFABRICATED BUILDINGS

Order 13-3901. Scope.

The intent and purpose of the following orders is to define approved methods for the wiring of prefabricated building sections, panels, or units designed for later erection or assembly as integral parts of buildings whether wired in the process of manufacture or at the site of erection or assembly.

Order 13-3902. Wiring Methods.

Only wiring methods recognized in this code shall be used.

Order 13-3903. Code Provisions to Apply.

The provisions of this code shall apply for the type of wiring method used and the type of construction employed.

Chapter 4. Equipment for General Use

SECTION 13-400. FLEXIBLE CORDS

Order 13-4001. General.

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

Order 13-4002. Types.

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

Order 13-4003. Use.

Flexible cord may be used only for (1) pendants; (2) wiring of fixtures; (3) connection of portable lamps, tools, or appliances; (4) elevator cables; (5) wiring of cranes and hoists; (6) for the connection of stationary equipment to facilitate their interchange; or (7) to prevent the transmission of noise or vibration. Flexible cord shall not be used (a) as a substitute for the fixed wiring of a structure; (b) where run through holes in walls, ceilings, or floors; (c) where run through doorways, windows, or similar openings; (d) where attached to building surfaces; or (e) where concealed behind building walls, ceilings or floors.

Order 13-4004. Splices.

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

Order 13-4005. Show-Windows and Show-Cases.

Flexible cords used in show-windows or in show-cases shall be of Type S, SO, SJ, SJO, ST, SJT, SU, SUO or AFS, except for the wiring of chain fixtures, and for supplying current to portable lamps and other merchandise for exhibition purposes.

Order 13-4006. Minimum Size.

Flexible cords shall not be smaller than No. 18, except that tinsel cords, or cords having equivalent characteristics, of smaller size may be approved for use with specific appliances.

Order 13-4007. Insulation—Over 300 Volts.

If the voltage between any two conductors exceeds 300, but does not exceed 600, flexible cord of No. 10 and smaller shall have rubber or thermoplastic insulation on the individual conductors at least 3/64 inch in thickness, unless Type S, SO, ST, SU, or SUO cord is used.

Order 13-4008. Overcurrent Protection.

Flexible cords not smaller than No. 18, and tinsel cords, or cords having equivalent characteristics, of smaller size approved for use with specific appliances, shall be considered as protected against overcurrent by the overcurrent devices described in Order 13-2403. Cords shall be not smaller than required by Table 3, Chapter 10, for the rated current of the appliance.

Order 13-4009. Pull at Joints and Terminals.

Flexible cords shall be so connected to devices and to fittings that tension will not be transmitted to joints or terminal screws. This shall be accomplished by a knot in the cord, winding with tape, by a special fitting designed for that purpose, or by other equivalent means.

SECTION 13-410. LIGHTING FIXTURES, LAMPHOLDERS, LAMPS, RECEPTACLES AND ROSETTES

GENERAL

Order 13-4101. Scope.

Lighting fixtures, lampholders, pendants, receptacles, and rosettes, incandescent filament lamps, arc lamps, electric discharge lamps, the wiring and equipment forming part of such lamps, fixtures and lighting installations shall conform to Orders 13-4102 to 13-4216 inclusive, except as otherwise provided in this code.

Order 13-4102. Application to Other Sections.

Equipment for use in hazardous locations shall conform to Section 13-500.

Order 13-4103. Live Parts.

Fixtures, lampholders, lamps, rosettes and receptacles, shall have no live parts normally exposed to contact, except in the case of cleat-type lampholders, receptacles and rosettes which are located at least 8 feet above the floor. Lampholders, receptacles and switches which have exposed accessible terminals shall not be installed in metal fixture canopies or in open bases of portable table or floor lamps.

PROVISIONS FOR FIXTURE LOCATIONS

Order 13-4111. Fixtures in Damp, Wet or Corrosive Locations.

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

Order 13-4112. Fixtures Near Combustible Material.

Fixtures shall be so constructed, or installed, or equipped with shades or guards that combustible material will not be subjected to temperatures in excess of 90C (194F).

Order 13-4113. Fixtures Over Combustible Material.

Lampholders installed over specially combustible material shall be of the unswitched type and unless individual switches are provided, shall be located at least 8 feet above the floor, or shall be otherwise so located or guarded that the lamps cannot be readily removed or damaged.

Order 13-4114. Fixtures in Show-windows.

No externally wired fixture other than of the chain type shall be used in a show-window. For use of cords in show-windows, see Order 13-4005.

Order 13-4115. Fixtures in Clothes Closets.

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

PROVISIONS AT FIXTURE OUTLET BOXES, CANOPIES AND PANS

Order 13-4121. Space for Conductors.

Canopies and outlet boxes taken together shall provide adequate space so that fixture conductors and their connecting devices may be properly installed.

Order 13-4122. Temperature Limit of Conductors in Outlet Boxes.

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

Order 13-4123. Outlet Boxes to be Covered.

In a completed installation, each outlet box shall be provided with a cover unless covered by means of a fixture canopy, lampholder, receptacle, rosette, or similar device.

Order 13-4124. Covering of Combustible Material at Outlet Boxes.

Any combustible wall or ceiling finish exposed between the edge of a fixture canopy or pan and an outlet box shall be covered with noncombustible material.

Order 13-4125. Connection of Fixtures.

In general, fluorescent fixtures when supported independently of the outlet box shall be connected through metal raceways or armored conductors. This requirement may be waived when cord-equipped fixtures are suspended directly below the outlet box and the exposed cord is not subject to strain or mechanical injury.

FIXTURE SUPPORTS

Order 13-4131. Support—General.

Fixtures, lampholders, rosettes, and receptacles shall be securely supported. A fixture which weighs more than 6 lbs. or exceeds 16 inches in any dimension shall not be supported by the screw shell of a lampholder.

Order 13-4132. Means of Support.

Where there is an outlet box, a gas pipe, or a fitting which will provide adequate support, a fixture shall be attached thereto; otherwise a fixture shall be supported as required by Order 13-3707. A fixture which weighs more than 50 lbs. shall be supported independently of the outlet box.

WIRING OF FIXTURES

Order 13-4141. Fixture Wiring—General.

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

Order 13-4142. Conductor Size.

Fixture conductors shall not be smaller than No. 18.

Order 13-4143. Conductor Insulation.

Fixtures shall be wired with conductors having insulation suitable for the current, voltage, and temperature to which the conductors will be subjected. Where fixtures are installed in damp, wet, or corrosive locations, conductors shall be of a type approved for such locations. For current carrying capacity of fixture wire, see Table 3, Chapter 10. For maximum operating temperature and voltage limitation of fixture wires, see Order 13-3102.

Order 13-4144. Conductors for Special Conditions.

Fixtures provided with mogul base screw-shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF fixture wire. Fixtures provided with other than mogul base screw-shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF fixture wire or Type AFC, AFPO, or AFPD flexible cord; except that where temperatures do not exceed 90C (194F) Type CF fixture wire or Type CFC, CFPD, or CFPO flexible cord may be used. Where temperatures do not exceed 60C (140F) Type T thermoplastic wire and Type TF and TFF fixture wire, Type R rubber-covered wire, Type RF-64, RF-32, FF-64, FF-32, RUF and RUFF fixture wire may be used, including use in fixtures of decorative type on which lamps of not over 60 watt rating are used in connection with imitation candles.

Order 13-4145. Conductors for Movable Parts.

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

Order 13-4146. Pendent Conductors for Incandescent Filament Lamps.

Pendent lampholders with permanently attached leads, if used in other than festoon wiring, shall be hung from separate stranded

rubber-covered conductors which are soldered directly to the circuit conductors but supported independently thereof. Such pendent conductors shall be not smaller than No. 14 for heavy-duty or medium-base screw-shell lampholders, nor, except for approved Christmas tree and decorative lighting outfits, smaller than No. 18 for intermediate-, or candelabra-base lampholders. If the pendent conductors are longer than 3 feet, they shall be twisted together.

Order 13-4147. Protection of Conductors.

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

Order 13-4148. Conductor Protection at Lampholders.

Where a metal lampholder is attached to a flexible cord, the inlet shall be equipped with an insulating bushing which, if threaded, shall not be smaller than nominal ⅜ inch pipe size. The edges of the bushing shall be rounded and all inside fins removed in order to provide a smooth bearing surface for the conductors.

Bushings having holes $\frac{9}{32}$ inch in diameter are suitable for use with plain pendent cord and holes $\frac{13}{32}$ inch in diameter with reinforced cord.

Order 13-4149. Connections, Splices and Taps.

Fixtures shall be so installed that the connections between the fixture conductors and the circuit conductors may be inspected without requiring the disconnection of any part of the wiring, unless the fixture is connected by means of a plug and receptacle. Splices and taps shall not be located within fixture arms or stems. No unnecessary splices or taps shall be made within or on a fixture. For approved means of making connections, see Order 13-1118.

Order 13-4150. Fixture Raceways.

Fixtures shall not be used as a raceway for circuit conductors unless the fixtures meet the requirements of approved raceways, except that the conductors of a single branch circuit may be carried through an installation of fixtures approved for end to end assembly to form a continuous raceway.

Individual fixtures of all types which are coupled, butted, telescoped, or connected together with metal raceways not over eighteen (18) inches in length, shall be considered as a single fixture.

Order 13-4151. Polarization of Fixtures.

Fixtures shall be so wired that the screw-shells of lampholders will be connected to the same fixture or circuit conductor or terminal. For polarity identification of conductors to screw-shells of lampholders, see Order 13-2004.

LAMPHOLDERS

Order 13-4156. Lampholders, Screw-Shell Type.

Lampholders of the screw-shell type shall be installed for use as lampholders only.

Order 13-4157. Double-pole Switched Lampholders.

Where used on unidentified 2-wire circuits tapped from the ungrounded conductors of multi-wire circuits, the switching device of lampholders of the switched type shall simultaneously disconnect both conductors of the circuit. See Order 13-2007.

Order 13-4158. Lampholders in Damp or Wet Locations.

Lampholders installed in damp or wet locations shall be of the weatherproof type.

RECEPTACLES

Order 13-4161. Rating and Type.

Receptacles installed for the attachment of portable cords shall be rated at not less than 15 amperes, 125 volts, or 10 amperes, 250 volts, and shall be of a type not suitable for use as lampholders.

Order 13-4162. Receptacles in Floors.

Receptacles located in floors shall be enclosed in floor boxes especially approved for the purpose, except where such receptacles are located in elevated floors of show windows or other locations free from mechanical injury, moisture and dirt, the standard approved type of flush receptable box may be used.

Order 13-4163. Receptacles in Damp or Wet Locations.

Receptacles installed in damp or wet locations shall be of the weatherproof type.

ROSETTES

Order 13-4165. Approved Types.

Fusible rosettes shall not be installed. Separable rosettes which make possible a change in polarity shall not be used. For construction specifications see Order 13-94104.

Order 13-4166. Rosettes in Damp or Wet Locations.

Rosettes installed in such locations shall be of the weatherproof type.

CONSTRUCTION

Order 13-4171. Combustible Shades and Enclosures.

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

Order 13-4172. Portable Handlamps.

Handlamps of the portable type supplied through flexible cords shall be of the molded composition or other type approved for the purpose. Brass-shell paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle. Where subject to mechanical damage or where lamps may come in contact with combustible material, handlamps shall be equipped with a substantial guard attached to the lampholder or the handle.

For Garages see Order 13-5108.

Order 13-4173. Marking.

All fixtures requiring ballasts or transformers shall be plainly marked with their electrical rating and the manufacturer's name, trade-mark or other suitable means of identification. The electrical rating shall include the voltage, frequency, and shall indicate the current rating of the unit including the ballast, transformer or auto-transformer.

SPECIAL PROVISIONS FOR FLUSH AND RECESSED FIXTURES

Order 13-4176. Approved Type.

Fixtures which are installed in recessed cavities in walls or ceilings shall be of an approved type and shall conform to Orders 13-4177 to 13-4180 inclusive.

Order 13-4177. Temperature.

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

Order 13-4178. Clearance.

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

Order 13-4179. Wiring.

Conductors having insulation suitable for the temperature encountered shall be used. Fixtures having terminal connections which operate at temperatures higher than 60C (140F) shall have circuit conductors as described in A or B below:

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

B. Tap connection conductors having an insulation suitable for the temperature encountered shall be run from the fixture terminal connection to an outlet box placed at least one foot from the fixture. Such a tap shall extend for at least four feet but not more than six feet and shall be in a suitable metal raceway.

Order 13-4180. Construction.

For the construction of flush and recessed fixtures, see Order 13-94105.

SPECIAL PROVISIONS FOR ELECTRIC DISCHARGE LIGHTING SYSTEMS OF 1,000 VOLTS OR LESS

Order 13-4181. General.

Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of 1,000 volts or less shall be of a type approved for such service. In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Orders 13-4182 to 13-4187 inclusive. Transformers of the oil-filled type shall not be used. The terminals of an electric discharge lamp shall be considered as alive if any lamp terminal is connected to a potential of more than 300 volts.

Order 13-4182. Direct-current Equipment.

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

Order 13-4183. Voltages—Dwelling Occupancies.

Equipment having an open-circuit voltage of more than 1,000 volts shall not be installed in dwelling occupancies. Equipment having an open-circuit voltage of more than 300 volts shall not be installed in dwelling occupancies unless such equipment is so designed that there shall be no exposed live parts when lamps are being inserted, in place, or being removed.

Order 13-4184. Fixture Mounting.

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

Order 13-4185. Auxiliary Equipment Not Integral With Fixture.

Auxiliary equipment, including reactors, capacitors, resistors, and similar equipment, where not installed as part of a lighting fixture assembly shall be enclosed in accessible, permanently-installed metal cabinets. Such separate equipment should be installed close to the lamps to keep the conductors between lamps and auxiliaries as short as possible. Where display cases are not permanently installed no portion of a secondary circuit may be included in more than a single case.

Order 13-4186. Auto-transformers.

An auto-transformer which is used as part of a ballast for supplying lighting units and which raises the voltage to more than 300 volts shall be supplied only by a grounded system.

Order 13-4187. Switches.

Snap switches shall conform to Order 13-3814.

SPECIAL PROVISIONS FOR ELECTRIC DISCHARGE LIGHTING SYSTEMS OF MORE THAN 1,000 VOLTS

Order 13-4191. General.

Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of more than 1,000 volts shall be of a type approved for such service. In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Order 13-4191 to Order 13-4203 inclusive. The terminal of an electric discharge lamp shall be considered as alive when any terminal is connected to a potential of more than 300 volts.

For signs and outline lighting, see Section 13-600.

Order 13-4192. Control.

Fixtures or lamp installations shall be controlled either singly or in groups by an externally-operable switch or circuit-breaker which will open all ungrounded primary conductors. The switch or circuit-breaker shall be located within sight of the fixtures or lamps, or it may be located elsewhere if it is provided with means for locking in the open position.

Order 13-4193. Switches.

Snap switches shall conform to Order 13-3814.

Order 13-4194. Transformer Ratings.

Transformers and ballasts shall have a secondary open-circuit voltage of not more than 15,000 volts with an allowance on test of 1,000 volts additional. The secondary current rating shall not be more than 240 milliamperes. When the open circuit voltage is more than 7,500 volts, the secondary current rating shall not be more than 120 milliamperes.

Order 13-4195. Transformer Type.

Transformers shall be of an approved enclosed type. Transformers of other than the askarel filled or air-cooled type shall not be used.

Order 13-4196. Transformer Secondary Connections.

The high-voltage windings of transformers shall not be connected in series or in parallel, except that for two transformers each having one end of its high-voltage winding grounded and connected to the enclosure, the high-voltage windings may be connected in series to form the equivalent of a mid-point grounded transformer. The grounded ends shall be connected by an insulated conductor not smaller than No. 14.

Order 13-4197. Location of Transformers.

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

Order 13-4198. Wiring Method, Secondary Conductors.

Approved gas-tube sign cable suitable for the voltage of the circuit shall be used. For installation of conductors see Order 13-6031.

Order 13-4199. Transformer Loading.

The lamps connected to any transformer shall be of such length and characteristics as not to cause a condition of continuous over-voltage on the transformer.

Order 13-4200. Lamp Supports.

Lamps shall be adequately supported as required in Order 13-6033.

Order 13-4201. Mechanical Injury.

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

Order 13-4202. Lamp Terminals and Lampholders.

Parts which must be removed for lamp replacement shall be hinged or fastened by an approved means. Lamps or lampholders or both shall be so designed that there shall be no exposed live parts when lamps are being inserted or are being removed, as provided in Order 13-6011.

Order 13-4203. Marking.

Each fixture or each secondary circuit of tubing having an open-circuit voltage of more than 1,000 volts shall have a clearly legible marking in letters not less than ¼ inch high reading "Caution _____ volts." The voltage indicated shall be the rated open-circuit voltage.

ARC LAMPS

Order 13-4205. General.

Arc lamps used in theatres shall conform to Order 13-5284, and arc lamps used in projection machines shall conform to Order 13-5431. Arc lamps used on constant-current systems shall conform to Order 13-7104.

GROUNDING

Order 13-4211. General.

Fixtures and lighting equipment shall be grounded as provided in Orders 13-4212 to 13-4216 inclusive.

Order 13-4212. Metallic Wiring Systems.

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

Order 13-4213. Non-metallic Wiring Systems.

Metal fixtures installed on outlets wired with knob-and-tube work, or non-metallic sheathed cable, on circuits operating at 150 volts or less to ground, shall be grounded except as follows:

1. Fixtures mounted on metal or metal lath ceilings or walls may be insulated from their supports and from the metal lath by the use of insulating joints or fixture supports and canopy insulators. See Order 13–4215.

2. Fixtures not mounted on metal or metal-lath ceilings or walls need be neither insulated nor grounded. See Order 13–4215.

Fixtures made of insulating materials, and lampholders with shells of insulating material, are recommended for use with wiring systems that do not afford a ready means for grounding the exposed noncurrent-carrying parts of fixtures and lampholders.

Order 13–4214. Equipment of More Than 150 Volts to Ground.

Metal fixtures, transformers and transformer enclosures on circuits operating at more than 150 volts to ground shall be grounded. Other exposed metal parts shall be grounded unless they are insulated from ground and other conducting surfaces and are inaccessible to unqualified persons, except that lamp tie wires, mounting screws, clips and decorative bands on glass lamps spaced not less than 1½ inches from lamp terminals need not be grounded.

Order 13–4215. Fixtures, Lampholders and Receptacle Plates Near Grounded Surfaces.

Ungrounded metal lighting fixtures, lampholders and face plates shall not be installed within 8 feet vertically or 5 feet horizontally of laundry tubs, bath tubs, shower baths, plumbing fixtures, steam pipes or other grounded metal work or grounded surfaces. Metal pull chains used at these locations shall be provided with insulating links.

Order 13–4216. Methods of Grounding.

Equipment shall be considered as grounded when mechanically connected in a permanent and effective manner to metal raceway, the armor of armored cable, the grounding conductor in non-metallic sheathed cable, a separate grounding conductor not smaller than No. 14, or to gas piping, provided that the raceway, armor, grounding conductor, or gas pipe is grounded in a manner specified in Section 13–250.

SECTION 13–422. APPLIANCES

Order 13–4221. Scope.

This section shall apply to electric appliances used in any occupancy.

Order 13–4222. Branch Circuit Required.

Every appliance shall be supplied by a branch circuit of one of the types specified in Section 13–210. Motor operated appliances shall also conform to the requirements of Section 13–430.

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

INSTALLATION OF APPLIANCES

Order 13–4231. Insulation of Cords.

Flexible cords used to connect heating appliances shall comply with the following:

A. *Appliances Requiring Heater Cords.* Flexible cords used to connect smoothing irons, or to connect portable electrically heated appliances rated at more than 50 watts and which produce temperatures in excess of 120C (250F) on surfaces with which the cord is liable to be in contact, shall be one of the types of approved heater cords listed in Table 31, Chapter 10.

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

Order 13–4232. Insulation of Appliances.

Portable appliances shall be provided with an adequate dielectric interposed between current carrying parts and those external surfaces which persons can touch, except for toasters, grills or other heating appliances in which the current carrying parts at high temperature are necessarily exposed. In locations where the dielectric is exposed to mechanical injury, it shall be suitably protected.

Order 13–4233. Portable Immersion Heaters.

Electric heaters of the portable immersion type shall be so constructed and installed that current carrying parts are effectively insulated from electrical contact with the substance in which immersed. The authority enforcing this code may make exception of special applications of apparatus where suitable precautionary measures are followed.

Order 13–4234. Protection of Combustible Material.

Each electrically heated appliance that is obviously intended by size, weight and service to be located in a fixed position shall be so placed as to provide ample protection between the appliance and adjacent combustible material.

Order 13–4235. Stands for Portable Appliances.

Each smoothing iron and other portable electrically heated appliance which is intended to be applied to combustible material shall be equipped with an approved stand, which may be a separate piece of equipment or may be a part of the appliance.

Order 13–4236. Signals for Heated Appliances.

In other than residence occupancies, each electrically heated appliance, or group of electrically heated appliances, intended to be applied to combustible material, shall be installed in connection with a signal unless the appliance is provided with an integral temperature limiting device.

Order 13–4237. Infra-Red Lamp Industrial Heating Appliances.

Infra-red heating lamps rated at 300 watts or less may be used with lampholders of the medium-base unswitched porcelain type, or other types approved for the purpose. Screw-shell lampholders shall not be used with infra-red lamps over 300 watts rating unless the lampholders are especially approved for the purpose. These lampholders may be connected to any of the branch circuits of Section 13–210 and, in industrial occupancies, may be operated in series on circuits of more than 150 volts to ground provided the voltage rating of the lampholders is not less than the circuit voltage.

Each section, panel or strip carrying a number of infra-red lampholders (including the internal wiring of such section, panel or strip) is considered an appliance. The terminal connection block of each such assembly is deemed an individual outlet.

Order 13–4238. Grounding.

Metal frames of portable and stationary electrically heated appliances, operating on circuits above 150 volts to ground, shall be grounded in the manner specified in Section 13–250; provided, however, that where this is impracticable, grounding may be omitted by special permission, in which case the frames shall be permanently and effectively insulated from the ground.

It is recommended that the frame be grounded in all cases. For methods of grounding frames of electric ranges see Orders 13–2557 and 13–2560.

CONTROL AND PROTECTION OF APPLIANCES

Order 13–4241. Disconnecting Means.

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

A. *Portable Appliances.* For portable appliances (including household ranges) a separable connector or an attachment plug and receptacle may serve as the disconnecting means. The rating of a receptacle or of a separable connector shall not be less than the rating of any appliance connected thereto, except that demand factors authorized elsewhere in this code may be applied. Attachment plug caps and connectors shall conform to the following:

1. Live Parts. They shall be so constructed and installed as to guard against inadvertent contact with live parts.

2. Interrupting Capacity. They shall be capable of interrupting their rated current without hazard to the operator.

3. Interchangeability. They shall be so designed that they will not fit into receptacles of lesser rating.

For household electric ranges, a plug and receptacle connection at the rear base of a range, if it is accessible from the front by removal of a drawer, is considered as meeting the intent of this rule.

B. *Stationary Appliances.* For stationary appliances rated at not over 300 volt amperes or ⅛ horsepower, the branch-circuit overcurrent device may serve as the disconnecting means. For stationary appliances of greater rating the branch-circuit switch or circuit-breaker may, if readily accessible to the user of the appliance, serve as the disconnecting means.

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

1. Multi-Family Dwellings. In multi-family (more than two) dwellings, the disconnecting means shall be within the apartment, or on the same floor as the apartment in which the appliance is installed, and may control lamps and other appliances.

2. Two-Family Dwellings. In two-family dwellings, the disconnecting means may be outside of the apartment in which the appliance is installed. This will permit an individual switch for the apartment to be used.

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

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

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

E. *Motor-Driven Appliances.* A switch or circuit-breaker which serves as the disconnecting means for a stationary motor-driven appliance of more than ⅛ horsepower shall be located within sight of the motor controller or shall be capable of being locked in the open position.

Order 13–4242. Overcurrent Protection.

Appliances, other than such motor-operated appliances as are required by Section 13–430 to have additional overcurrent protection, shall be considered as protected against overcurrent when supplied by one of the circuits of Section 13–210 and in accordance with the requirements therein specified. A range, hot plate, or similar appliance with surface heating elements, and having a rating of more than 70 amperes, shall have two or more subdivided circuits, each provided with overcurrent protection not exceeding 50 amperes. Infra-red lamp heating appliances shall have overcurrent protection not exceeding 50 amperes.

Order 13–4243. Automatic Flatirons.

It is recommended that electrically heated smoothing irons be equipped with an approved temperature limiting device.

MARKING OF APPLIANCES

Order 13–4261. Name Plate.

Each electric appliance shall be provided with a name plate, giving the maker's name and the normal rating in volts and amperes, or in volts and watts.

Note: The name plate shall be in a place where it will be accessible when equipment is in use.

Order 13-4262. Marking of Heating Elements.

Individual heating elements which are a part of an electric appliance containing more than one heating element shall each be legibly marked with normal rating in volts and amperes, or in volts and watts.

SECTION 13-430. MOTORS AND CONTROLLERS

GENERAL

Order 13-4301. General.

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

Order 13-4302. Application of Other Requirements.

Motors and controllers shall also comply with the provisions of the following:

Auto-transformers	Order 13-2003
Capacitors	Order 13-4608
Cranes and Hoists	Section 13-610
Elevators	Section 13-620
Garages	Order 13-5103
Hazardous Location	Section 13-500
Machine Tools	Section 13-670
Motion-picture Projectors	Orders 13-5411, 13-5416
Motion-picture Studios	Orders 13-5310, 13-5311
Organs	Order 13-6503
Resistors and Reactors	Section 13-470
Theaters	Order 13-5246

Order 13-4303. Overheating From Dust Accumulations.

In locations where dust or flying material will collect on or in motors in such quantities as to seriously interfere with the ventilation or cooling of motors, and thereby cause dangerous temperatures, suitable types of enclosed motors which will not overheat under the prevailing conditions, shall be used. Especially severe conditions may require the use of enclosed pipe ventilated motors, or enclosure in separate dust-tight rooms, properly ventilated from a source of clean air.

Order 13-4304. Identification of Motors.

A motor shall be provided with a name-plate which shall give the maker's name, the rating in volts and amperes, including those of the secondary if a wound-rotor type of motor, the normal full-load speed and the interval during which it can operate at full load starting cold, before reaching its rated temperature. The time interval shall be 5, 15, 30, or 60 minutes, or continuous. For a motor rated at ⅛ horsepower or larger, the horsepower shall be marked, except that the motors of arc-welders and sealed (hermetic type) refrigeration compressor motors may be marked in amperes. Sealed (hermetic type) refrigeration compressor motors which are not marked in horsepower shall be marked with the full-load current and the locked rotor current in amperes. A motor provided with a protective device integral with the motor (see Order 13-4322), shall have a marking which will

so indicate. For an alternating current motor rated at ½ horsepower or larger, except a polyphase wound-rotor motor, the name-plate shall be marked with a code letter to show its input in kilovolt-amperes with locked rotor, selected from the table given in Order 13-94304, Chapter 9.

The code letter indicating motor input with locked rotor must be in an individual block on the name-plate, properly identified. This code letter is to be used for determining branch-circuit over-current protection by reference to Table 26, Chapter 10, as provided in Order 13-4342.

Order 13-4305. Identification of Controllers.

A controller shall be marked with the maker's name or identification symbol, the voltage, the current or horsepower rating, and such other data as may be needed to properly indicate the motors for which it is suitable.

Where a controller is built in as an integral part of a motor or of a motor-generator set, the controller need not be individually marked since the necessary data must be on the motor nameplate.

Order 13-4306. Identification of Terminals.

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

Order 13-4307. Wiring Space in Enclosures.

Enclosures for controllers and disconnecting means for motors shall not be used as junction boxes, troughs, or raceways for conductors feeding through or tapping off to other apparatus unless designs are employed which provide adequate space for this purpose.

Order 13-4308. Enclosures.

Suitable guards or enclosures shall be provided to protect exposed current carrying parts of motors and the insulation of motor leads where installed directly under equipment, or in other locations where dripping or spraying oil, water, or other injurious liquid may occur, unless the motor is designed for the existing conditions.

Order 13-4309. Current-Carrying Capacities.

Whenever the current rating of a motor is used to determine the current-carrying capacity of conductors, switches, branch-circuit overcurrent devices, etc., the values given in Tables 21 to 24 of Chapter 10, including footnotes, shall be used in lieu of actual current rating marked on the motor nameplate. Motor running overcurrent protection shall be based on the motor nameplate current rating. If a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Tables 21 to 24, prorated if necessary.

Order 13-4310. Location of Motors.

Motors shall be located so that maintenance such as lubrication of bearings and replacing of brushes can be readily accomplished. Open

motors having commutators or collector rings shall be located or protected so that sparks cannot reach adjacent combustible material. This does not prohibit the installation of these motors on wooden floors or supports.

SIZE OF CONDUCTORS FOR MOTOR CIRCUITS

Order 13–4311. General.

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

Order 13–4312. Individual Motor.

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

Classification of Service	Percentages of Name-Plate Current Rating			
	5- Minute Rating	15-Minute Rating	30 and 60-Minute Rating	Continuous Rating
Short-Time Duty				
Operating valves, raising or lowering rolls, etc.	110	120	150	---
Intermittent Duty				
Freight and passenger elevators, tool heads, pumps, drawbridges, turntables, single-operator arc welders for manual welding, etc.	85	85	90*	140
Periodic Duty	85	90	95	140
Rolls, ore and coal-handling machines, etc.	110	120	150	200
Varying duty	or lower at the discretion of the authorities enforcing the regulations.			

The conductors between stationary motors, rated 1 H. P. or less, and the separate terminal enclosures permitted in Order 13–4439B may be smaller than No. 14 but not smaller than No. 18, provided they have current-carrying capacity as specified above.

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

Any motor is considered to be for continuous duty unless the nature of the apparatus which it drives is such that the motor will not operate continuously with load under any condition of use.

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

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

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

Order 13–4313. Wound-Rotor Secondary.

The conductors connecting the secondary of a wound-rotor A. C. motor to its controller shall have a carrying capacity which is not less than 125 per cent of the full load secondary current of the motor if for continuous duty. For other than continuous duty, these conductors shall have a carrying capacity, in per cent of full load secondary current, not less than that specified in the table in Order 13–4312. Where the secondary resistor is separate from the controller, the carrying capacity of the conductors between controller and resistor shall be not less than that given in the following table:

Resistor Duty Classification	Carrying Capacity of Wire in Per Cent of Full Load Secondary Current
Light starting duty	35
Heavy starting duty	45
Extra heavy starting duty	55
Light intermittent duty	65
Medium intermittent duty	75
Heavy intermittent duty	85
Continuous duty	110

Order 13–4314. Conductors Supplying Several Motors.

Conductors supplying two or more motors shall have a current carrying capacity of not less than 125 per cent of the full load current rating of the highest rated motor in the group plus the sum of the full load current ratings of the remainder of the motors in the group.

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

Order 13–4315. Combination Load.

Conductors supplying a motor load, and in addition a lighting or appliance load as computed from Section 13–220 and other applicable orders, shall have a current carrying capacity sufficient for the lighting or appliance load plus the required capacity for the motor load determined in accordance with Order 13–4314, or, for a single motor, in accordance with Order 13–4312.

Order 13–4316. Demand Factor.

Where a reduced heating of the conductors results from motors operating on a duty cycle, intermittently, or from all motors not operating at one time, the authority enforcing this code may grant permission for feeder conductors to be of a capacity less than specified in the Orders 13–4314 and 13–4315, provided the conductor is of sufficient carrying capacity for the maximum load determined by the sizes and number of motors supplied and the character of their loads and duties.

MOTOR OVERCURRENT PROTECTION

Order 13–4321. General.

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

Order 13-4322. Continuous Duty Motors.

Each continuous duty motor shall be protected against running overcurrent as follows:

A. *More Than One Horsepower.* For a motor rated more than one horsepower, this protection shall be secured by the use of one of the following means:

1. A separate overcurrent device which is responsive to motor current. This device shall be rated or set at not more than 125 per cent of the motor full-load current rating for motors marked to have a temperature rise not over 40C, and at not more than 115 per cent for all other types of motors. This value may be modified as permitted by Order 13-4324.

2. A protective device integral with the motor which is responsive to motor current or to both motor current and temperature. This device must be approved for use with the motor which it protects on the basis that it will interrupt current to the motor when the motor is operated in an ambient temperature of 40C and with overcurrent of the percentage values given in paragraph 1 of this order. This value may be modified as permitted by Order 13-4324. If the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it must be so arranged that the opening of the control circuit will result in interruption of current to the motor.

B. *One Horsepower or Less, Manually Started.* Any motor of one horsepower or less which is manually started and which is within sight from the starter location, shall be considered as protected against overcurrent by the overcurrent device protecting the conductors of the branch circuit. This branch circuit overcurrent device shall not be larger than that specified in Table 20, Chapter 10, except that any such motor may be used at 125 volts or less on a branch circuit protected at 20 amperes. Any such motor which is out of sight from the starter location shall be protected as specified in paragraph C for automatically started motors.

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

C. *One Horsepower or Less, Automatically Started.* Any motor of one horsepower or less which is started automatically shall be protected against overcurrent by the use of one of the following means:

1. A separate overcurrent device which is responsive to motor current. This device shall be rated or set at not more than 125 per cent of the motor full-load current rating for motors marked to have a temperature rise not over 40C, and at not more than 115 per cent for all other types of motors. This value may be modified as permitted by Order 13-4324.

2. A protective device integral with the motor which is responsive to motor current or to both motor current and temperature. This device must be approved for use with the motor which it protects on the basis that it will prevent dangerous overheating of the motor due to overload or failure to start. If the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it must be so arranged that the opening of the control circuit will result in interruption of current to the motor.

3. If part of an approved assembly which does not normally subject the motor to overloads and which is also equipped with other safety controls (such as the safety combustion controls of a domestic oil burner) which protect the motor against damage due to stalled rotor current. Where such protective equipment is used it shall be indicated on the name-plate of the assembly where it will be visible after installation.

4. If the impedance of the motor windings is sufficient to prevent overheating due to failure to start, the motor may be protected as specified in paragraph B for manually started motors.

Many alternating-current motors of less than 1/20 horsepower, such as clock motors, series motors, etc., and also some larger motors such as torque motors, come within this classification. It does not include split-phase motors having automatic switches to disconnect the starting windings.

D. *Wound-Rotor Secondaries.* The secondary circuits of wound-rotor alternating-current motors, including conductors, controllers, resistors, etc., shall be considered as protected against overcurrent by the motor-running over-current device.

Order 13-4323. Intermittent and Similar Duty.

A motor used for a condition of service which is inherently short time, intermittent, periodic, or varying duty (as illustrated by the table in Order 13-3412) is considered as protected against overcurrent by the branch circuit overcurrent device, provided the overcurrent protection does not exceed that specified in Tables 26 and 27, Chapter 10.

Any motor is considered to be for continuous duty unless the nature of the apparatus which it drives is such that the motor cannot operate continuously with load under any condition of use.

Order 13-4324. Selection of Size of Protective Device.

Where the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses, non-adjustable circuit-breakers, thermal cutouts, thermal relays, the heating elements of thermal trip motor switches, or possible settings of adjustable circuit-breakers adequate to carry the load, the next higher size, rating or setting may be used, but not higher than 140 per cent of the full-load current rating of motors marked to have a temperature rise not over 40C and not higher than 130 per cent of the full-load current rating for all other motors. If not shunted during the starting period of the motor (see Order 13-4325), the protective device shall have sufficient time delay to permit the motor to start and accelerate its load.

Order 13-4325. Shunting During Starting Period.

If the motor is manually started (including starting with a magnetic starter having push-button control), the running overcurrent

protection may be shunted or cut out of circuit during the starting period of the motor, provided the device by which the overcurrent protection is shunted or cut out cannot be left in the starting position, and the motor shall be considered as protected against overcurrent during the starting period if fuses or time-delay circuit-breakers rated or set at not over 400 per cent of the full-load current of the motor, are so located in the circuit as to be operative during the starting period of the motor. The motor-running overcurrent protection shall not be shunted or cut out during the starting period if the motor is automatically started.

Order 13–4326. Fuses—In Which Conductor.

If fuses are used for motor-running protection, a fuse shall be inserted in each ungrounded conductor, except that a fuse shall also be inserted in a grounded conductor under the circumstances set forth in the note following Order 13–4327 for circuits supplied by wye-delta or delta-wye connected transformers.

Order 13–4327. Devices Other Than Fuses—In Which Conductor.

If devices other than fuses are used for motor running protection, the following table shall govern the minimum allowable number and location of overcurrent units such as trip coils, relays, or thermal cutouts.

Kind of Motor	Supply System	Number and location of overcurrent units, such as trip coils, relays or thermal cut-outs
1-phase A.C. or D.C.	2-wire, 1 phase A.C. or D.C. ungrounded	1 in either conductor
1-phase A.C. or D.C.	2-wire, 1 phase A.C. or D.C., one conductor grounded	1 in ungrounded conductor
1-phase A.C. or D.C.	3-wire, 1-phase A.C. or D.C., grounded-neutral	1 in either ungrounded conductor
2-phase A.C.	3-wire, 2-phase A.C., ungrounded	2, one in each phase
2-phase A.C.	3-wire, 2-phase A.C., one conductor grounded	2 in ungrounded conductors
2-phase A.C.	4-wire, 2-phase A.C. grounded or ungrounded	2, one per phase in ungrounded conductors
2-phase A.C.	5-wire, 2-phase A.C., grounded neutral or ungrounded	2, one per phase in any ungrounded phase wire
3-phase A.C.	3-wire, 3-phase A.C., ungrounded	*2 in any 2 conductors
3-phase A.C.	3-wire, 3-phase A.C., one conductor grounded	*2 in ungrounded conductors
3-phase A.C.	3-wire, 3-phase A.C grounded-neutral	*2 in any 2 conductors
3-phase A.C.	4-wire, 3-phase A.C. grounded-neutral or ungrounded	*2 in any 2 conductors, except the neutral

*Note. In the case of distribution systems supplying wye-delta or delta-wye connected transformers (having the wye neutral point in the primary ungrounded or not connected to the circuit) the authority enforcing this code may require that three running overcurrent units be provided for the protection of three-phase 3-wire motors, if field experience in the territory of the authority indicates that a third unit is desirable because of motor winding failures at times of primary single phase failures, unless the motors are otherwise adequately protected.

Order 13–4328. Number of Conductors Disconnected by Overcurrent Device.

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

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

Order 13–4329. Motor Controller as Running Protection.

A motor controller may also serve as the running overcurrent device if the number of overcurrent units complies with the foregoing Order 13–4327; and if these overcurrent units are operative in both the starting and running position in the case of a D. C. motor, and in the running position in the case of an A. C. motor.

Order 13–4330. Thermal Cutouts and Relays.

Thermal cutouts, thermal relays, and other devices for motor running protection which are not capable of opening short circuits, shall be protected by fuses or circuit-breakers with ratings or settings of not over 4 times the rating of the motor for which they are designed, unless approved for group installation, and marked to indicate the maximum size of fuse by which they must be protected.

Order 13–4331. Rating of Protective Device.

Motor running overcurrent devices other than fuses shall have a rating of at least 115 per cent of the full load current rating of the motor.

Order 13–4332. With Lamps or Receptacles.

Overcurrent protection for motors used on branch circuits which also supply lamps or receptacles, as permitted in Section 13–210, shall be provided as follows:

A. One or more motors without individual overcurrent protection may be connected to the branch circuits described in Section 13–210 only when the limiting conditions specified for each of two or more motors in paragraph A of Order 13–4343 are complied with.

B. Motors of larger ratings than specified in paragraph A of Order 13–4343 may be connected to the branch circuits described in Section 13–210 only if provided with individual running overcurrent protection selected to protect the motor as specified in Order 13–4322. Both the controller and the motor-running overcurrent device shall be approved for group installation with the protective device of the branch circuit to which the motor is connected.

C. If a motor is connected to a branch circuit by means of a plug and receptacle, and individual overcurrent protection is omitted as provided in paragraph A, the rating of the plug and receptacle shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts. If individual overcurrent protection is required as provided in paragraph B for a motor or motor-operated appliance provided with an attachment plug for attaching to the branch circuit through a receptacle, the running overcurrent device shall be an integral part of the motor or of the appliance. The rating of the plug and receptacle shall be assumed to determine the rating of the circuit to which the motor may be connected, as provided in Section 13–210.

D. The overcurrent device protecting a branch circuit to which a motor or motor-operated appliance is connected shall have sufficient time delay to permit the motor to start and accelerate its load.

Order 13-4333. Automatic Restarting.

A motor-running protective device which can restart a motor automatically after overcurrent tripping shall not be installed unless approved for use with the motor which it protects. A motor which can restart automatically after shutdown shall not be installed so that its automatic restarting can result in injury to persons.

MOTOR-BRANCH-CIRCUIT OVERCURRENT PROTECTION

Order 13-4341. General.

The following provisions specify overcurrent devices intended to protect the motor branch circuit conductors, the motor control apparatus, and the motors against overcurrent due to short circuits or grounds. They are in addition to or amendatory of the provisions of Section 13-240.

Order 13-4342. Rating or Setting for Individual Motor.

The motor branch circuit overcurrent device shall be capable of carrying the starting current of the motor. Overcurrent protection shall be considered as being obtained when this overcurrent device has a rating or setting not exceeding the values given in Tables 26 or 27, Chapter 10; provided that where the overcurrent protection specified in the table is not sufficient for the starting current of the motor, it may be increased, but shall in no case exceed 400 per cent of the motor full load current.

Fuse ratings calculated on this basis are given in columns 7, 8, 9 and 10 of Table 20, Chapter 10.

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

Order 13-4343. Several Motors on One Branch Circuit.

Two or more motors may be connected to the same branch circuit under the following conditions:

A. Two or more motors each not exceeding 1 horsepower in rating and each having a full-load rated current not exceeding 6 amperes, may be used on a branch circuit protected at not more than 20 amperes at 125 volts or less, or 15 amperes at 600 volts or less. Individual running overcurrent protection is unnecessary for such motors unless required by the provisions of Order 13-4322.

B. Two or more motors of any ratings, each having individual running overcurrent protection, may be connected to one branch circuit provided all of the following conditions are complied with:

1. Each motor-running overcurrent device must be approved for group installation.

2. Each motor controller must be approved for group installation.

3. The branch circuit must be protected by fuses having a rating equal to that specified in Order 13-4342 for the largest motor connected to the branch circuit plus an amount equal to the sum of the full load current ratings of all other motors connected to the circuit.

4. The branch circuit fuses must not be larger than allowed by Order 13-4330 for the thermal cutout or relay protecting the smallest motor of the group.

5. The conductors of any tap supplying a single motor need not have individual branch circuit protection, provided they comply with either of the following: (1) no conductor to the motor shall have a current carrying capacity less than that of the branch circuit conductors, or (2) no conductor to the motor shall have a current-carrying capacity less than one-third that of the branch circuit conductors, with a minimum in accordance with Order 13-4312; the conductors to the motor running protective device being not more than 25 feet long and being protected from mechanical injury.

Order 13-4344. Combined Overcurrent Protection.

Motor branch circuit overcurrent protection and motor running overcurrent protection may be combined in a single overcurrent device if the rating or setting of the device provides the running overcurrent protection specified in Order 13-4322.

Order 13-4345. Overcurrent Devices—In Which Conductor.

Overcurrent devices shall comply with the provisions of Order 13-2405.

Order 13-4346. Capacity of Fuseholder.

If fuses are used for motor-branch-circuit overcurrent protection, the fuseholders shall not be of a smaller size than required to accommodate the fuses specified by Table 20; except that when appropriate fuses for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Table 20 may be used.

Order 13-4347. Rating of Circuit-Breaker.

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

Order 13-4348. Feeder Taps in Inaccessible Location.

If the location of a tap to the feeder conductors is not accessible, the motor branch circuit overcurrent device may be placed where it will be accessible, provided the conductors between the tap and the overcurrent device have the same current carrying capacity as the feeder; or provided they have a current carrying capacity of at least ⅓ that of the feeder and are not more than 25 feet long (where feeders are at a greater elevation, this distance may be increased to 50 feet) and are protected from mechanical injury.

Order 13-4349. Selection or Setting of Protective Device.

If the values for branch circuit protective devices given in Table 26 or Table 27 do not correspond to the standard sizes or ratings of fuses, non-adjustable circuit-breakers, or thermal devices, or possible settings of adjustable circuit-breakers adequate to carry the load, the next higher size, rating or setting may be used.

MOTOR FEEDER OVERCURRENT PROTECTION

Order 13–4361. General.

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

Order 13–4362. Rating or Setting—Motor Load.

A feeder which supplies motors shall be provided with overcurrent protection which shall not be greater than the largest rating or setting of the branch circuit protective device, for any motor of the group (based on Tables 26 and 27, Chapter 10), plus the sum of the full load currents of the other motors of the group.

If two or more motors of equal horsepower rating are the largest in the group, one of these motors should be considered as the largest for the above calculations.

If two or more motors of a group must be started simultaneously, it may be necessary to install larger feeder conductors and correspondingly larger ratings or settings of feeder overcurrent protection.

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

Order 13–4363. Rating or Setting—Power and Light Loads.

If a feeder supplies a motor load, and in addition a lighting or a lighting and appliance load, the feeder overcurrent protective device may have a rating or setting sufficient to carry the lighting or the lighting and appliance load as determined in accordance with Sections 13–210 and 13–220, plus, for a single motor, the rating permitted by Order 13–4342; and, for two or more motors, the rating permitted by Order 13–4362.

REMOTE CONTROL CIRCUITS

Order 13–4371. General.

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

Order 13–4372. Overcurrent Protection.

Conductors of control circuits of remote controlled equipment shall be protected against overcurrent in accordance with Order 13–2403, paragraph G, except that such conductors shall be considered as being properly protected by the branch circuit overcurrent devices under any one of the following conditions:

A. If the rating or setting of the branch circuit overcurrent device is not more than 500 per cent of the carrying capacity of the control circuit conductors.

B. If the controlled device and the point of control (start and stop buttons, pressure switch, thermostatic switch, etc.) are both located on the same machine and the control circuit does not extend beyond the machine.

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

Order 13–4373. Mechanical Protection of Conductor.

Where damage to a remote control circuit would constitute a hazard, all conductors of such remote control circuit shall be installed in conduit or be otherwise suitably protected from mechanical injury outside the control device itself.

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

Order 13–4374. Switching.

Control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means specified in Order 13–4406 is in the open position. The disconnecting means may consist of two separate devices, one of which disconnects the motor and the controller from the source of power supply, and the other, the control circuit from its power supply. If two separate devices are used they should be located immediately adjacent one to the other. If a transformer or other device is used to obtain a reduced voltage for control circuits, such transformer or other device shall be connected to the load side of the disconnecting means.

MOTOR CONTROLLERS

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

Order 13–4381. General.

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

See Diagram No. 20, Chapter 10.

Order 13–4382. Suitability.

Each controller shall be capable of starting and stopping the motor which it controls, and for an alternating current motor shall be capable of interrupting the stalled rotor current of the motor.

Order 13–4383. Rating.

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

A. Stationary Motor of ⅛ Horsepower or Less. For a stationary motor rated at ⅛ horsepower or less, that is normally left running and is so constructed that it cannot be damaged by overload or failure to start, such as clock motors and the like, the branch circuit overcurrent device may serve as the controller.

B. Stationary Motor of 2 Horsepower or Less. For a stationary motor rated at 2 horsepower or less, and 300 volts or less, the controller may be a general use switch having an ampere rating at least twice the full load current rating of the motor.

C. Portable Motor of ⅓ Horsepower or Less. For a portable motor rated at ⅓ horsepower or less, the controller may be an attachment plug and receptacle.

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

Order 13–4384. Need Not Open All Conductors.

Except when it serves also as a disconnecting means (see Order 13–4407), the controller need not open all conductors to the motor.

Order 13–4385. In Grounded Conductors.

One pole of the controller may be placed in a permanently grounded conductor provided the controller is so designed that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.

Order 13–4386. In Sight from the Controller Location.

A motor and its driven machinery shall be within sight from the controller location unless one of the following conditions is complied with:

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

B. A manually-operable switch, which will prevent the starting of the motor, is placed within sight from the motor location. This switch may be placed in the remote-control circuit of a remote-control type of switch.

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

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

D. As otherwise specified in Section 13–500 of this code.

Order 13–4387. Number of Motors Served by Each Controller.

Each motor shall be provided with an individual controller, except that for motors of 600 volts or less a single controller may serve a group of motors under any one of the following conditions:

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

B. If a group of motors is under the protection of one overcurrent device as permitted in paragraph A of Order 13–4343.

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

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

Order 13–4388. Adjustable Speed Motors.

Adjustable speed motors, if controlled by means of field regulation, shall be so equipped and connected that they cannot be started under weakened field, unless the motor is designed for such starting.

Order 13–4389. Speed Limitation.

Machines of the following types shall be provided with speed limiting devices, unless the inherent characteristics of the machines, the system, or the load and the mechanical connection thereto, are such as to safely limit the speed, or unless the machine is always under the manual control of a qualified operator.

A. Separately excited direct current motors.

B. Series Motors.

C. Motor generators and converters which can be driven at excessive speed from the direct current end, as by a reversal of current or decrease in load.

Order 13–4390. Fuseholder Rating.

The rating of a combination fuseholder and switch used as a motor controller shall be such that the fuseholder will accommodate the size of fuse specified in Table 20, Chapter 10 for motor running protection.

DISCONNECTING MEANS

Order 13–4401. General.

The following provisions specify disconnecting means for motors and controllers capable of disconnecting them from the circuit.

See Diagram No. 20, Chapter 10.

Order 13–4402. Type.

The disconnecting means shall be a motor-circuit switch, rated in horsepower, or a circuit-breaker, except as permitted in the following paragraphs A, B, C, D, or E. Every switch in the motor branch circuit within sight from the controller location shall comply with these requirements.

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

A. *One-Eighth Horsepower or Less.* For stationary motors of ⅛ horsepower or less, the branch-circuit overcurrent device may serve as the disconnecting means.

B. *Two Horsepower or Less.* For stationary motors rated at 2 horsepower or less and 300 volts or less, the disconnecting means may be a general-use switch having an ampere rating at least twice the full-load current rating of the motor.

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

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

2. The compensator (1) is capable of interrupting the stalled-rotor current of the motor, (2) is provided with a no-voltage release, and (3) is provided with running-overcurrent protection not exceeding 125 per cent of the motor full-load current rating.

3. Separate fuses or a circuit-breaker, rated or set at not more than 150 per cent of the motor full-load current, are provided in the motor branch circuit.

D. *Exceeding 50 Horsepower.* For stationary motors rated at more than 50 horsepower, the disconnecting means may be a motor-circuit switch also rated in amperes, a general-use switch, or an isolating switch.

It is recommended that isolating switches for motors exceeding 50 horsepower, not capable of interrupting stalled-rotor currents, be plainly marked "Do not open under load".

E. *Portable Motors.* For portable motors an attachment plug and receptacle may serve as the disconnecting means.

Order 13-4403. Carrying Capacity.

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

Order 13-4404. Grounded Conductors.

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

Order 13-4405. To Be Indicating.

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

Order 13-4406. To Disconnect Both Motor and Controller.

The disconnecting means shall disconnect both the motor and the controller from all ungrounded supply conductors. The disconnecting means may be in the same enclosure with the controller.

Order 13-4407. Switch or Circuit-Breaker as Both Controller and Disconnecting Means.

A switch or circuit-breaker complying with the provisions of Order 13-4383 may serve as both controller and disconnecting means if it opens all ungrounded conductors to the motor, is protected by an overcurrent device (which may be the branch circuit fuses) which opens all ungrounded conductors to the switch or circuit-breaker, and is one of the following types:

A. An air-break switch, operable directly by applying the hand to a lever or handle.

B. A circuit-breaker operable directly by applying the hand to a lever or handle.

C. An oil switch used on a circuit whose rating does not exceed 600 volts or 100 amperes, or on a circuit exceeding this capacity if under expert supervision and by special permission.

The oil switch or circuit-breaker specified above may be both power and manually operable. If power operable, provision should be made to lock it in the open position.

The overcurrent device protecting the controller may be part of the controller assembly or may be separate.

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

Order 13-4408. Service Switch as Disconnecting Means.

If an installation consists of a single motor, the service switch may serve as the disconnecting means, provided it conforms to the requirements of this section, and is within sight of the controller.

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

Order 13-4409. In Sight of Controller.

The disconnecting means shall be located in sight from the controller or be arranged to be locked in the open position.

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

Order 13-4410. Motors Served by a Single Disconnecting Means.

Each motor shall be provided with individual disconnecting means, except that for motors of 600 volts or less a single disconnecting means may serve a group of motors under any one of the following conditions. The disconnecting means serving a group of motors shall have a rating not less than is required by Order 13-4402 for a single motor whose rating equals the sum of the horsepowers or currents of all the motors of the group.

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

B. If a group of motors is under the protection of one set of overcurrent devices as permitted by paragraph A of Order 13-4343.

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

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

Order 13-4411. Readily Accessible.

The disconnecting means shall be readily accessible.

REQUIREMENTS FOR OVER 600 VOLTS

Order 13-4421. General.

The following provisions recognize the additional hazard due to the use of high voltage. They are in addition to or amendatory of the other provisions of this section. Other requirements for circuits and equipment operating at more than 600 volts are in Section 13-710.

Order 13-4422. More Than 7500 Volts.

Motors operating at more than 7500 volts between conductors shall be installed in fire resistive motor rooms.

Order 13-4423. Motor Overcurrent Protection.

Running overcurrent protection for a motor of over 600 volts shall consist either of a circuit-breaker, or of overcurrent units integral with the controller which shall simultaneously open all ungrounded conductors to the motor. The overcurrent device shall have a setting as specified elsewhere in this section for motor running protection.

Order 13-4424. Circuit Overcurrent Protection.

Each motor branch circuit and feeder of more than 600 volts shall be protected against overcurrent by one of the following means:

A. A circuit-breaker of suitable rating so arranged that it can be serviced without hazard.

B. Fuses of the oil-filled or other suitable type. Fuses shall be used with suitable disconnecting means or they shall be of a type which can also serve as the disconnecting means. They shall be so arranged that they cannot be re-fused or replaced while they are energized. The ratings of fuses shall be limited to the values permitted by Order 13-7143.

Order 13-4425. Disconnecting Means.

The circuit-breaker or the fuses specified in Order 13-4424 may constitute the disconnecting means if they conform to the other applicable requirements of this section.

PROTECTION OF LIVE PARTS—ALL VOLTAGES

Order 13-4431. General.

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

Order 13-4432. Where Required.

Exposed live parts of motors and controllers operating at 50 volts or more between terminals, except for stationary motors having commutators, collectors and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground, shall be guarded against accidental contact by enclosure, or by location as follows:

A. By installation in a room or enclosure which is accessible only to qualified persons;

B. By installation on a suitable balcony, gallery or platform, so elevated and arranged as to exclude unqualified persons;

C. By elevation 8 feet or more above the floor;

D. So that it will be protected by a guard rail when the motor operates at 600 volts or less.

Order 13-4433. Guards for Attendants.

If the live parts of motors or controllers operating at more than 150 volts to ground are guarded against accidental contact only by location as specified in Order 13-4432, and if adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms. Where necessary, steps and handrails should be installed on or about large machines to afford safe access to parts which must be examined or adjusted during operation.

GROUNDING

Order 13-4435. General.

The following provisions specify the grounding of motor and controller frames to prevent a potential above ground in the event of accidental contact between live parts and frames. Insulation, isolation, or guarding are suitable alternatives for motors under certain conditions.

Order 13-4436. Stationary Motors.

The frames of stationary motors shall be grounded if any of the following conditions exist:

A. If supplied by means of metal clad wiring.

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

C. If in a hazardous location. (See Section 13-500).

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

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

Order 13-4437. Portable Motors.

The frames of portable motors which operate at more than 150 volts to ground shall be guarded or grounded. See paragraph C of Order 13-2545 on grounding of portable appliances in other than residential occupancies.

It is recommended that the frames of motors which operate at less than 150 volts to ground be grounded if this can be readily accomplished. See paragraph B of Order 13-2559 for color of grounding conductor.

Order 13-4438. Controllers.

Controller cases, except those attached to ungrounded portable equipment and except the lined covers of snap switches, shall be grounded regardless of voltage.

Order 13-4439. Method of Grounding.

Grounding where required shall be done in the manner specified in Section 13-250.

A. *Grounding Through Terminal Housings.* If the wiring to fixed motors is in armored cable or metal raceways, junction boxes to house motor terminals shall be provided. These housings shall be of ample size to properly make connections, they shall be of substantial metal construction, and the armor of the cable or the metal raceways shall be connected to them in the manner specified in Section 13-250.

B. *Separation of Junction Box from Motor.* The junction box required by paragraph A may be separated from the motor not more than 6 feet provided the leads to the motor are armored cable or armored cord or are stranded leads enclosed in flexible or rigid conduit or electrical metallic tubing not smaller than ⅜ inch electrical trade size, the armor or raceway being connected both to the motor and to the box. If stranded leads are used, protected as specified above, they shall not be larger than No. 10, and shall comply with other requirements of the code for conductors to be used in raceways.

SECTION 13–445. GENERATORS

Order 13–4451. Location.

Generators shall be located in dry places and also so as to meet the requirements for motors in Order 13–4310. Generators installed in hazardous locations as described in Section 13–500, or in other locations as described in Sections 13–510, 13–520, and 13–530, shall also comply with the provisions of those sections.

It is recommended that waterproof covers be provided for use in emergency.

Order 13–4452. Identification.

Each generator shall be provided with a name plate giving the maker's name, the rating in kilowatts or kilovolt amperes, the normal volts and amperes corresponding to the rating, and the revolutions per minute.

Order 13–4453. Drip Pans.

Generators shall be provided with suitable drip pans if required by the authority enforcing this code.

Order 13–4454. Overcurrent Protection.

Constant potential generators, except alternating current generators and their exciters, shall be protected from excessive current by circuit-breakers or fuses.

A. *Two-Wire Generators.* Two-wire, direct current generators may have overcurrent protection in one conductor only if the over-current device is actuated by the entire current generated, except that in the shunt field. The overcurrent device shall not open the shunt field.

B. *65 Volts or Less.* Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by the overcurrent device protecting the motor if these devices will operate when the generators are delivering not more than 150 per cent of their full load rated current.

C. *Balancer Sets.* Two-wire, direct current generators used in conjunction with balancer sets to obtain neutrals for 3-wire systems shall be equipped with overcurrent devices which will disconnect the 3-wire system in the case of excessive unbalancing of voltages or currents.

D. *3-Wire, Direct Current Generators.* Three-wire, direct current generators, whether compound or shunt wound, shall be equipped with overcurrent devices, one in each armature lead, and so connected as to be actuated by the entire current from the armature. Such overcurrent devices shall consist either of a double pole, double coil circuit-breaker, or of a 4-pole circuit-breaker connected in the main and equalizer leads and tripped by two overcurrent devices, one in each armature lead. Such protective devices shall be so interlocked that no one pole can be opened without simultaneously disconnecting both leads of the armature from the system.

Order 13–4455. Size of Conductors.

The conductors from the generator terminals to supplied equipment shall have a carrying capacity not less than 115 per cent of the name plate current rating. Neutral conductors shall be the same size as the conductors of the outside legs.

Order 13–4456. Protection of Live Parts.

Live parts of generators of more than 150 volts to ground shall not be exposed to accidental contact if accessible to unqualified persons.

Order 13–4457. Guards for Attendants.

Where necessary for the safety of attendants the provisions of Order 13–4433 shall be complied with.

Order 13–4458. Grounding.

If a generator operates at a terminal voltage in excess of 150 volts to ground, the frame shall be grounded in the manner specified in Section 13–250. If the frame is not grounded, it shall be permanently and effectively insulated from the ground.

SECTION 13–450. TRANSFORMERS AND TRANSFORMER VAULTS (Including Secondary Ties)

Order 13–4501. Application.

This section applies to the installation of all transformers except: (1) current transformers; (2) dry-type transformers which constitute a component part of other apparatus and which conform to the requirements for such apparatus; (3) transformers for use with X-ray and high-frequency; (4) transformers used with Class 2 remote-control, low energy power and signal circuits which shall conform to Section 13–725 on control circuits; (5) transformers for sign and outline lighting which shall conform to Section 13–600; and (6) transformers for electric discharge lighting which shall conform to Section 13–410.

This section applies to the installation of transformers in hazardous locations except as modified by Section 13–500.

See also Section 13–710, Circuits and Equipment Operating at More than 600 Volts Between Conductors, and Service Installations Over 600 Volts as referred to in Section 13–230.

GENERAL PROVISIONS

Order 13-4511. Location.

They shall be located and arranged to minimize possible life and fire hazards. The location of transformer vaults as affected by ventilating requirements is covered elsewhere in this section.

Order 13-4512. Overcurrent Protection.

Overcurrent protection shall conform to the following. As used in this order, the word "transformer" means a transformer or a bank of transformers operating as a unit.

A. *Primary Side.* Each transformer shall be protected by an overcurrent device in the primary connection, rated or set at not more than 250 per cent of the rated primary current of the transformer, except that an individual overcurrent device is not required if the primary circuit overcurrent device provides the protection specified in this paragraph, and except as provided in paragraph B of this Order.

B. *Primary and Secondary Side.* A transformer having an overcurrent device in the secondary connection, rated or set at not more than 250 per cent of the rated secondary current of the transformer, or a transformer equipped with a coordinated thermal overload protection by the manufacturer, is not required to have an individual overcurrent device in the primary connection provided the primary feeder overcurrent device is rated or set to open at a current value not more than six times the rated current of the transformer, for transformers having not more than six per cent impedance, and not more than four times rated current of the transformer for transformers having more than six but not more than ten per cent impedance.

C. *Potential (Voltage Transformers).* Potential transformers should have primary fuses. The fuse rating should not exceed 10 amperes for circuits of 600 volts or less, and 3 amperes for circuits of more than 600 volts. A resistor should be connected in series with high tension fuses if necessary to limit the possible short-circuit current to a value within the interrupting capacity of the fuse.

Order 13-4513. Secondary Ties.

As used in this order the word "transformer" means a transformer or a bank of transformers operating as a unit. A secondary tie is a circuit operating at 600 volts or less between phases which connects two power sources or power supply points, such as the secondaries of two transformers. The tie may consist of one or more conductors per phase.

A. *Tie Circuits.* The circuits shall be provided at each end with overcurrent protection as required in Section 13-240 of this code, except under the conditions described in sub-paragraphs 1 and 2 of this order, in which cases, the overcurrent protection may be in accordance with sub-paragraph 3 of this order.

1. Loads at Transformer Supply Points Only. If all loads are connected at the transformer supply points at each end of the tie and

overcurrent protection is not provided in accordance with Section 13-240, the rated current-carrying capacity of the tie shall be not less than 67 per cent of the rated secondary current of the largest transformer connected to the secondary tie system.

2. Loads Connected Between Transformer Supply Points. If load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with Section 13-240, the rated current-carrying capacity of the tie shall be not less than 100 per cent of the rated secondary current of the largest transformer connected to the secondary tie system except as otherwise provided in sub-paragraph 4.

3. Tie Circuit Protection. Under the conditions described in sub-paragraphs 1 and 2 of this order, both ends of each tie conductor shall be equipped with a protective device which will open at a predetermined temperature of the tie conductor under short circuit conditions. This protection shall consist of the following: (1) a fusible link cable connector, terminal or lug, commonly known as a limiter, each being of a size corresponding with that of the conductor and of approved construction and characteristics according to the operating voltage and the type of insulation on the tie conductors, or (2) automatic circuit-breakers actuated by devices having comparable current-time characteristics.

4. Interconnection of Phase Conductors Between Transformer Supply Points. If the tie consists of more than one conductor per phase, the conductors of each phase shall be interconnected in order to establish a load supply point, and the protection specified in sub-paragraph 3 shall be provided in each tie conductor at this point, except as follows:

Loads may be connected to the individual conductors of a multiple-conductor tie without interconnecting the conductors of each phase and without the protection specified in sub-paragraph 3 at load connection points provided; the tie conductors of each phase have a combined capacity not less than 133 per cent of the rated secondary current of the largest transformer connected to the secondary tie system; the total load of such taps does not exceed the rated secondary current of the largest transformer; the loads are equally divided on each phase and on the individual conductors of each phase as far as practicable.

5. Tie Circuit Control. If the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end which when open will de-energize the associated tie conductors and limiters. The current rating of the switch shall be not less than the rated current of the conductors connected to the switch. It shall be capable of opening its rated current, and it shall be constructed so that it will not open under the magnetic forces resulting from short-circuit current.

B. *Overcurrent Protection for Secondary Connections.* When secondary ties are used an overcurrent device rated or set at not more than 250 per cent of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer,

and in addition an automatic circuit-breaker actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

Order 13–4514. Parallel Operation.

Transformers may be operated in parallel and protected as a unit if their electrical characteristics are such that they will divide the load in proportion to their rating.

Order 13–4515. Guarding.

Transformers shall be guarded as follows:

A. *Mechanical Protection.* Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes if the transformers are located where they are exposed to mechanical injury.

B. *Exposed Live Parts.* The transformer installation shall conform with the provisions for "Guarding of Live Parts" in Order 13–1113.

C. *Voltage Warning.* The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

Order 13–4516. Grounding.

Exposed non-current carrying metal parts of transformer installations including fences shall be grounded under the conditions and in the manner prescribed for electrical equipment and other exposed metal parts in Section 13–250.

Order 13–4517. Name-plate.

Each transformer shall be provided with a name-plate giving the name of the manufacturer; rated kilovolt-amperes, frequency, primary and secondary voltage; and the amount and kind of insulating liquid, if any, if the transformer rating exceeds 25 kva. If Class B insulation as defined in American Standard for Transformers C 57.1 is used in the construction of dry-type transformers of more than 100 kva, the name-plate shall so indicate.

SPECIFIC PROVISIONS APPLICABLE TO DIFFERENT TYPES OF TRANSFORMERS

Order 13–4521. Dry-type Transformers Installed Indoors.

Transformers rated 100 kva or less shall have a separation of at least 12 inches from combustible material unless separated therefrom by a fire-resistant heat-insulating barrier, or unless of a rating not exceeding 600 volts and completely enclosed except for ventilating openings.

Transformers of more than 100 kva rating shall be installed in a transformer room of fire-resistant construction unless they are constructed with Class B insulation, as defined in American Standard for Transformers C 57.1, and are separated from combustible material not less than 6 feet horizontally and 12 feet vertically or are separated therefrom by a fire-resistant heat-insulating barrier.

Transformers rated more than 15,000 volts shall be installed in a vault.

Order 13–4522. Askarel-insulated Transformers Installed Indoors.

Askarel-insulated transformers rated in excess of 25 kva shall be furnished with a pressure-relief vent. If installed in a poorly ventilated place they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure relief vent shall be connected to a chimney or flue which will carry such gases outside the building. Askarel-insulated transformers rated more than 15,000 volts shall be installed in a vault.

Order 13–4523. Oil-insulated Transformers Installed Indoors.

Oil-insulated transformers shall be installed in a vault constructed as specified in this section except as follows:

A. *Not Over 100 kva Total Capacity.* The provisions for transformer vaults specified in this section apply except that the vault may be constructed of reinforced concrete not less than 4 inches thick.

B. *Not Over 600 Volts.* A vault is not required provided suitable arrangements are made where necessary to prevent a transformer oil fire igniting other materials, and the total transformer capacity in one location does not exceed 10 kva in a section of the building classified as combustible, or 75 kva where the surrounding structure is classified as fire-resistant construction.

C. *Furnace Transformers.* Electric furnace transformers of a total rating not exceeding 75 kva may be installed without a vault in a building or room of fire-resistant construction if arrangements necessary to prevent a transformer oil fire spreading to other combustible material are provided.

D. *Detached Buildings.* Transformers may be installed in a building which does not conform with the provisions specified in this code for transformer vaults provided neither the building nor its contents presents a fire hazard to any other building or property, and provided the building is used only in supplying electric service and is accessible only to qualified persons.

Order 13–4524. Oil-insulated Transformers Installed Outdoors.

Combustible material, combustible buildings and parts of buildings, fire escapes, door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on, attached to, or adjacent to a building or combustible material. Space separations, fire-resistant barriers and enclosures which confine the oil of a ruptured transformer tank are recognized safeguards. One or more of these safeguards shall be applied according to the degree of hazard involved in cases where the transformer installation presents a fire hazard. Oil enclosures may consist of fire-resistant dikes, curbed areas or basins,

or trenches filled with coarse crushed stone. Oil enclosures shall be provided with trapped drains in cases where the exposure and the quantity of oil involved are such that removal of oil is important.

PROVISIONS FOR TRANSFORMER VAULTS

Order 13-4541. Location.

Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

Order 13-4542. Walls, Roof, and Floor.

The walls and roofs of vaults shall consist of reinforced concrete not less than 6 inches thick, masonry of brick not less than 8 inches thick, of 12-inch load-bearing hollow tile or 12-inch load-bearing hollow concrete building units. The inside wall and roof surface of vaults constructed of hollow tile and hollow concrete building units shall have a coating of cement or gypsum plaster not less than ¾ inches thick. The vault shall have a concrete floor not less than 4 inches thick. Building walls and floors which meet these requirements may serve for the floor, roof and one or more walls of the vault. The quality of the material used in the construction of the vault shall be of the grade approved by the inspection authority having jurisdiction.

Order 13-4543. Doorways.

Any doorway leading from the vault into the building shall be protected as follows:

A. *Type of Door.* Each doorway shall be provided with a tight-fitting door of a type approved for openings in Class A situations as defined in the 1939 edition of the standard of the National Board of Fire Underwriters for Protection of Openings in Walls and Partitions Against Fire. The authority enforcing this code may require such a door on each side of the wall if conditions warrant.

B. *Sills.* A door sill or curb of sufficient height to confine within the vault the oil from the largest transformer shall be provided and in no case shall the height be less than 4 inches.

C. *Locks.* Entrance doors shall be equipped with locks, and doors shall be kept locked, access being allowed only to qualified persons. Locks and latches shall be so arranged that the door may be readily and quickly opened from the inside.

Order 13-4544. Ventilation.

The ventilation shall be adequate to prevent a transformer temperature in excess of the values prescribed in American Standard for Transformers C 57.1.

Order 13-4545. Ventilation Openings.

Openings for ventilation shall be provided in accordance with the following:

A. *Location.* Ventilation openings shall be located as far away as possible from doors, windows, fire escapes, and combustible material.

B. *Arrangement.* Vaults ventilated by natural circulation of air may have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof; or all of the area required for ventilation may be provided in one or more openings in or near the roof.

C. *Size.* In the case of vaults ventilated to an outdoor area without using ducts or flues the combined net area of all ventilating openings after deducting the area occupied by screens, gratings, or louvers, shall be not less than 3 square inches per kva of transformer capacity in service except that the net area shall be not less than 1 square foot for any capacity under 50 kva.

D. *Covering.* Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

E. *Dampers.* If automatic dampers are used in the ventilation openings in vaults containing oil-insulated transformers, the actuating device should be made to function at a temperature resulting from fire and not at a temperature which might prevail as a result of an overheated transformer or bank of transformers. Care should be taken to avoid unintentional closing of automatic dampers.

F. *Ducts.* Ventilating ducts shall be constructed of fire-resistive material.

Order 13-4546. Drainage.

If practicable, vaults containing more than 100 kva transformer capacity shall be provided with a drain which will carry off any accumulation of oil or water that may collect in the vault. The floor shall be pitched to the drain opening.

Order 13-4547. Water Pipes and Accessories.

Any pipe or duct systems foreign to the electrical installation should not enter or pass through a transformer vault. If the presence of such foreign systems cannot be avoided, appurtenances thereto which require maintenance at regular intervals shall not be located inside the vault. Arrangements shall be made if necessary to avoid possible trouble from condensation, leaks, and breaks in such foreign systems. Piping or other facilities provided for fire protection or for water-cooled transformers are not deemed to be foreign to the electrical installation.

Order 13-4548. Storage in Vaults.

Materials shall not be stored in transformer vaults.

SECTION 13–460. CAPACITORS

Order 13–4601. Application of Other Sections.

This section shall not apply to special capacitors constituting a component part of other apparatus and conforming with the requirements for such apparatus. Capacitors installed in hazardous locations shall comply with the provisions of this section except as modified by Section 13–500.

Order 13–4602. Location.

Capacitors shall be enclosed in vaults complying with the provisions of Section 13–450 unless they are askarel insulated or unless each unit contains not more than 3 gallons of a combustible oil.

Order 13–4603. Mechanical Protection.

Appropriate provisions shall be made to minimize the possibility of damage to capacitors from external causes if the capacitors are located where they are exposed to mechanical injury.

Order 13–4604. Transformers Used with Capacitors.

Transformers used with capacitors shall be installed in accordance with Section 13–450. The kva rating shall be not less than 135 per cent of the capacitor kva rating.

Order 13–4605. Drainage of Stored Charge.

Capacitors shall be provided with a means of draining the stored charge.

A. *Time of Discharge.* The residual voltage of a capacitor shall be reduced to 50 volts or less within one minute after the capacitor is disconnected from the source of supply in the case of capacitors rated 600 volts or less and in five minutes in the case of capacitors rated more than 600 volts.

B. *Means of Discharge.* The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used. The windings of motors, of transformers, or of other equipment directly connected to capacitors without a switch or overcurrent device interposed, constitutes a suitable discharge means.

Order 13–4606. Capacitor Rating.

The rating of capacitors which are connected on the load side of a motor over-current device shall not exceed the value required to raise the no-load power-factor of the motor to unity. Capacitors of this maximum rating will usually result in a full-load power-factor of 95 to 98 per cent. The maximum capacitor ratings permitted for use with open-type, three-phase, sixty-cycle induction motors are given in Table 30, Ch. 10.

Order 13–4607. Capacitor Circuits.

Capacitor circuits shall conform to the following:

A. *Conductor Rating.* The rating of capacitor circuit conductors shall be not less than 135 per cent of the rated current of the capacitor. The rating of conductors which connect a capacitor to the terminals of a motor or to motor circuit conductors shall be not less than one-third the rating of the motor circuit conductors or the rating shall be determined as explained above if this method gives a greater value.

B. *Overcurrent Protection.* An overcurrent device shall be provided in each ungrounded conductor, except that an overcurrent device is not required for a capacitor connected on the load side of a motor overcurrent device. The rating or setting of the overcurrent device shall be as low as practicable without causing unnecessary opening of the circuit. A rating or setting of 165 to 250 per cent of the rated current of the capacitor will be suitable under average conditions although the setting or rating may have to exceed 250 per cent in some cases.

C. *Disconnecting Means.* A disconnecting device shall be provided in each ungrounded conductor except that a disconnecting device is not required for a capacitor connected on the load side of a motor disconnecting device. The disconnecting device need not open all ungrounded conductors simultaneously. The disconnecting device may be used for disconnecting the capacitor from the line as a regular operating procedure. The continuous current carrying capacity of the disconnecting device shall be not less than 135 per cent of the rated current of the capacitor.

Order 13–4608. Rating or Setting of the Motor Overcurrent Device.

If a motor installation includes a capacitor connected on the load side of the motor overcurrent device, and the overcurrent device used can be adjusted as explained below, the rating or setting of the motor overcurrent device shall be determined as provided in Order 13–4322 except that instead of using the full-load rated current of the motor as provided in that section a lower value corresponding with the improved power-factor of the motor circuit shall be used. The reduction in the full-load current required is specified in Table 30, Chapter 10, for open-frame, three-phase, sixty-cycle induction motors. Order 13–4312 applies with respect to the rating of the motor circuit conductors.

Order 13–4609. Grounding.

Capacitor cases shall be grounded in accordance with Section 13–250.

Order 13–4610. Guarding.

All live parts of capacitors which are connected to circuits of more than 600 volts between conductors and are accessible to unqualified persons, shall be enclosed or isolated. For isolation by elevation, see Order 13–7162.

Order 13-4611. Name-Plate.

Each capacitor shall be provided with a name-plate giving the maker's name, rated voltage, frequency, kva or amperes, number of phases, and if liquid-filled, the amount of liquid in gallons, together with a statement that the liquid will or will not burn, as the case may be. The name-plate shall indicate whether or not a capacitor unit has a discharge device inside the case.

SECTION 13-470. RESISTORS AND REACTORS

For Rheostats see Orders 13-4305, 13-4306 and 13-94303.

Order 13-4701. Location.

Resistors and reactors shall not be placed where exposed to mechanical injury. If in the immediate vicinity of easily ignitible material they shall be of the oil immersed type or shall be enclosed in metal boxes or cabinets. See Section 13-500 for Hazardous Locations.

Order 13-4702. Space Separation.

Unless attached to a switchboard or other noncombustible material, or unless mounted as provided in Order 13-4703, resistors and reactors shall be separated from combustible material by a distance of not less than 1 foot.

Order 13-4703. On or In Proximity to Combustible Material.

If placed within a distance of 1 foot from combustible material, resistors and reactors shall be installed as follows:

A. *Slab or Panel.* They shall be attached to a slab or panel of noncombustible, nonabsorptive material such as slate, soapstone, or marble.

B. *Size of Slab.* The slab shall extend beyond the edges of the device and shall have a thickness proportioned to the size and weight of the device but shall not be less than ½ inch thick.

C. *Supports.* The slab shall be secured in position by supports independent of those fastening the device to the slab. Bolts which support the device shall be countersunk at least ⅛ inch below the rear surface of the slab and shall be covered with insulating material.

Order 13-4704. Mounting.

Casings when mounted on plane surfaces shall make contact with such surfaces only at the point of support, an air space of at least ¼ inch being maintained between the casings and surfaces.

Order 13-4705. Conductor Insulation.

If insulated conductors are used for connection between resistance elements and controllers, the conductors shall be suitable for an operating temperature of not less than 90C (194F), except that for motor-starting service other conductor insulations may be used. For elevator motor starting service, see paragraph B of Order 13-6204.

Order 13-4706. Incandescent Lamps as Resistors.

Incandescent lamps may be used as protective resistors for automatic controllers, or may by special permission be used as resistors in series with other devices and shall conform to the following:

A. *Mounting.* They shall be mounted in porcelain receptacles on non-combustible supports.

B. *Voltage.* They shall be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated.

C. *Name Plate.* They shall be provided with a name plate, permanently attached, giving the wattage and voltage of the lamp to be used in each receptacle.

D. *Not Carry Main Current.* They shall not carry or control the main current nor constitute the regulating resistance of the device.

SECTION 13-480. STORAGE BATTERIES

Order 13-4801. Scope.

The provisions of this section shall apply to all stationary installations of storage batteries using acid or alkali as the electrolyte and consisting of a number of cells connected in series with a nominal voltage in excess of 16 volts.

Order 13-4802. Definition of Nominal Voltage.

The nominal battery voltage shall be calculated on the basis of 2.0 volts per cell for the lead acid type, and 1.2 volts per cell for the alkali type.

Order 13-4803. Wiring and Apparatus Supplied from Batteries.

Wiring, appliances, and apparatus supplied from storage batteries shall be subject to the requirements of this code applying to wiring, appliances, and apparatus operating at the same voltage, except as otherwise provided for communication systems in Section 13-800.

Order 13-4804. Insulation of Batteries of Not Over 250 Volts.

The provisions of this order shall apply to storage batteries having the cells so connected as to operate at a nominal battery voltage not exceeding 250 volts.

A. *Lead Acid Batteries.* Cells in lead lined wood tanks, where the number of cells in series does not exceed 25, shall be supported individually on glass or glazed porcelain insulators. If the number of the cells in series exceeds 25, the cells shall be supported individually on oil insulators.

B. *Alkali Type Batteries.* Cells of the alkali type in jars made of conducting material shall be installed in trays of non-ducting material, with not over 20 cells in a series circuit in any one such tray, or the cells may be supported singly or in groups on porcelain or other suitable insulators.

C. *Unsealed Jars.* Cells in unsealed jars made of nonconductive material shall be assembled in trays of glass or supported on glass or glazed porcelain insulators; or, if installed on a rack, shall be supported singly or in groups on glass or other suitable insulators.

D. *Sealed Rubber Jars.* Cells in sealed rubber or composition containers shall require no additional insulating support if the total nominal voltage of all cells in series does not exceed 150 volts. If the total voltage exceeds 150 volts, batteries shall be sectionalized into groups of 150 volts or less and each group shall have the individual cells installed in trays or on racks. If trays or racks are required for this type of cell, such trays or racks shall be supported on glass or glazed porcelain insulators or oil type insulators.

E. *Sealed Glass Jars.* Cells in sealed glass jars, with or without wood trays, require no additional insulation.

Order 13-4805. Insulation of Batteries of Over 250 Volts.

The provisions of Order 13-4804 shall apply to storage batteries having the cells so connected as to operate at a nominal voltage exceeding 250 volts and, in addition, the provisions of this order shall also apply to such batteries.

A. Cells shall be installed in groups having a total nominal voltage of not over 250 volts, in trays or on racks supported on oil insulators; except that if each individual cell, or sub-group in the tray or rack, is supported on oil insulators, no additional insulation for the group need be provided; and except that cells of not over 10 ampere hour capacity in sealed glass jars may be grouped in trays, the total nominal voltage of all cells in such a group not to exceed 250 volts, and each such tray to be supported on glass or glazed porcelain insulators, the trays being mounted on racks supported on oil insulators with a total nominal voltage of not over 500 volts for all cells in series on each insulated rack.

Maximum protection is secured by sectionalizing high voltage batteries into cell groups insulated from each other.

Order 13-4806. Racks and Trays.

Racks and trays shall conform to the following:

A. *Racks.* Racks, as required in this section, refer to frames designed to support cells or trays. They shall be substantial, and made of:

1. Wood, so treated as to be resistant to deteriorating action by the electrolyte; or

2. Metal, so treated as to be resistant to deteriorating action by the electrolyte, and provided with non-conducting members directly supporting the cells or with suitable insulating material on conducting members; or

3. Other similar suitable construction.

B. *Trays.* Trays refer to frames such as crates or shallow boxes usually of wood or other nonconducting material, so constructed or treated as to be resistant to deteriorating action by the electrolyte.

Order 13-4807. Battery Rooms.

Battery rooms shall conform to the following:

A. *Use.* Separate battery rooms or enclosures shall be required only for batteries in unsealed jars and tanks where the aggregate capacity at the 8-hour discharge rate exceeds 5 kilowatt hours.

B. *Wiring Method.* In storage battery rooms, bare conductors, open wiring, or conductors in rigid conduit or electrical metallic tubing shall be used as the wiring method.

C. *Varnished Cambric Conductors.* Varnished cambric covered conductors, Type V, shall not be used.

D. *Bare Conductors.* Bare conductors shall not be taped.

E. *Raceway.* Rigid metal conduit, or electrical metallic tubing, if used, shall be of corrosion resistant material or shall be suitably protected from corrosion.

F. *Terminals.* If metal raceway or other metallic covering is used in the battery room, at least 12 inches of the conductor at the end connected to a cell terminal shall be free from the raceway or metallic covering and shall be bushed by a substantial glazed insulating bushing. The end of the raceway shall be sealed tightly to resist the entrance of electrolyte by spray or by creepage. Sealing compound, rubber insulating tape or other suitable material shall be used for this purpose.

G. *Ventilation* Provision shall be made for sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture in the battery room.

Chapter 5. Special Occupancies

SECTION 13-500. HAZARDOUS LOCATIONS

Order 13-5001. Scope.

The provisions of this section apply to locations in which the authority enforcing this code judges the apparatus and wiring to be subject to the conditions indicated by the following classifications. It is intended that each room, section or area (including motor and generator rooms, and rooms for the enclosure of control equipment) shall be considered individually in determining its classification. Except as modified by this section, all other applicable rules contained in this code shall apply to electrical apparatus and wiring installed in hazardous locations. For garages, see Section 13-510. For definition of "approved" as used in this section see Section 13-100.

The term explosion-proof as used in this section shall mean: enclosed in a case which is capable of withstanding an explosion of a specified gas or vapor which may occur within it, and of preventing the ignition of the specified gas or vapor surrounding the enclosure by sparks, flashes or explosions of the gas or vapor within.

Through the exercise of ingenuity in the layout of electrical installations for hazardous locations, it is frequently possible to locate much of the equipment in less hazardous or in non-hazardous areas and thus to reduce the amount of special equipment required.

Order 13-5002. Special Precaution.

The intent of this section is to require a form of construction of equipment, and of installation that will insure safe performance under conditions of proper use and maintenance. It, therefore, is assumed that inspection authorities and users will exercise more than ordinary care with regard to installation and maintenance.

The explosive characteristics of various atmospheric mixtures of hazardous gases, vapors and dusts depend on the specific hazardous material involved. It is necessary, therefore, that equipment be approved not only for the class of location but also for the specific gas, vapor or dust that will be present.

For purposes of testing and approval, various atmospheric mixtures have been grouped on the basis of their explosive characteristics, and facilities have been made available for testing and approval of equipment for use in the following atmospheric groups:

Group A, Atmospheres containing acetylene;

Group B, Atmospheres containing hydrogen, or gases or vapors of equivalent hazard such as manufactured gas;

Group C, Atmospheres containing ethyl ether vapor;

Group D, Atmospheres containing gasoline, petroleum, naphtha, alcohols, acetone, lacquer solvent vapors, and natural gas;

Group E, Atmospheres containing metal dust;

Group F, Atmospheres containing carbon black, coal or coke dust;

Group G, Atmospheres containing grain dust.

Order 13-5003. Paints, Lacquers and Finishes.

The provisions of this order shall apply to locations which are or may be hazardous because of readily ignitible deposits or residues from paints, varnishes, lacquers or other types of finishes.

Hazardous amounts of readily ignitible deposits or residues may occur in spray booths and their ventilating ducts and in other locations where some types of paints, lacquers or finishes are regularly or frequently applied by spraying, dipping, brushing, or by other means; or where drippage, spillage or leakage of such paints, lacquers or finishes may occur. Some residues are not readily ignitible, and some are relatively non-hazardous. The character and quantity of materials that are or may be used should be taken into consideration in the application of these orders, and in determination of the extent of the affected area.

For locations where volatile flammable solvents or thinners may introduce hazards in addition to those of readily ignitible deposits or residues, refer also to Order 13-5004.

A. *Electrical Equipment.* Unless specifically approved for the location, no electrical equipment or apparatus shall be installed or used where it may be subject to hazardous accumulations of readily ignitible deposits or residues, except as follows:

1. Wiring in rigid conduit or in threaded boxes or fittings containing no taps, splices or terminal connections may be installed in such locations.

2. High voltage grids and their connections which are a part of electrostatic paint spraying or detearing equipment may be installed in such locations when adequate protection against spark-over and accidental grounding is provided, and when the installation and operation of such equipment is judged to be acceptable by the authority enforcing this Code.

B. *Lighting Through Glass Panels.* Illumination of hazardous areas through panels of glass or other transparent material is permissible only if fixed lighting units are used as the source of illumination, if the panel effectively isolates the hazardous area from the area in which the lighting unit is located, if the lighting unit itself is approved for the location in which it is located, if the transparent panel is of a material or is so protected that breakage will be unlikely, and if the arrangement is such that normal accumulations of hazardous residue on the exposed surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

Order 13-5004. Class I Locations.

Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include the following:

A. *Class I, Division 1.* Locations (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions, (2) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because

of leakage, or (3) in which breakdown or faulty operation of equipment or processes which might release hazardous concentrations of flammable gases or vapors, might also cause simultaneous failure of electrical equipment.

This classification would usually include locations where flammable volatile liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction apparatus using volatile flammable solvents; portions of cleaning and dyeing plants where hazardous liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; pump rooms for flammable gas or for volatile flammable liquids; and all other locations where hazardous concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

B. *Class I, Division 2.* Locations (1) in which flammable volatile liquids or flammable gases are handled, processed or used, but in which the hazardous liquids, vapors or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment, (2) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of the ventilating equipment, or (3) which are adjacent to Class I, Division 1 locations, and to which hazardous concentrations of gases or vapors might occasionally be communicated.

This classification would usually include locations where flammable volatile liquids or flammable gases or vapors are used, but which, in the judgment of the code enforcing authority, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of hazardous material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that should receive consideration in determining the classification and extent of each hazardous area.

Piping without valves, checks, meters and similar devices would not ordinarily be deemed to introduce a hazardous condition even though used for hazardous liquids or gases. Locations used for the storage of hazardous liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless subject to other hazardous conditions also.

Order 13-5005. Class II Locations.

Class II locations are those which are hazardous because of the presence of combustible dust. Class II locations shall include the following:

A. *Class II, Division 1.* Locations (1) in which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures, (2) where mechanical failure or abnormal operation of machinery or equipment might

cause such mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or from other causes, or (3) in which dusts of an electrically conducting nature may be present.

This classification would usually include the working areas of grain handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpers, open conveyors or spouts, open bins or hoppers, mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all-metal collectors vented to the outside), and all similar dust producing machinery and equipment in grain processing plants, starch plants, sugar pulverizing plants, malting plants, hay grinding plants, and other occupancies of similar nature; coal pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitible mixtures.

Combustible dusts which are electrically non-conducting will include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Electrically conducting non-metallic dusts will include dusts from pulverized coal, coke and charcoal. Metallic dusts from magnesium, aluminum and aluminum bronze are particularly hazardous, and every precaution must be taken to avoid ignition and explosion.

B. *Class II, Division 2.* Locations in which combustible dust will not normally be in suspension in the air, or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus, in quantities sufficient to produce explosive or ignitible mixtures, but (1) where deposits or accumulations of such dust may be sufficient to interfere with the safe dissipation of heat from electrical equipment or apparatus, or (2) where such deposits or accumulations of dust on, in, or in the vicinity of electrical equipment might be ignited by arcs, sparks or burning material from such equipment.

Locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on, in or in the vicinity of electrical equipment, would include rooms and areas containing only closed spouting and conveyors, closed bins or hoppers, or machines and equipment from which appreciable quantities of dust would escape only under abnormal operating conditions; rooms or areas adjacent to locations described in paragraph A of this order, and into which explosive or ignitible concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formation of explosive or ignitible concentrations of suspended dust is prevented by the operation of effective dust control equipment; warehouses and shipping rooms where dust producing materials are stored or handled only in bags or containers; and other similar locations.

Order 13-5006. Class III Locations.

Class III locations are those which are hazardous because of the presence of easily ignitible fibers or flyings, but in which such fibers

or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitible mixtures. Class III locations shall include the following:

A. *Class III, Division 1.* Locations in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured or used.

Such locations would include some parts of rayon, cotton and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions.

B. *Class III, Division 2.* Locations in which easily ignitible fibers are stored or handled (except in process of manufacture).

Easily ignitible fibers and flyings will include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste, kapok, Spanish moss, excelsior and other materials of similar nature.

CLASS I—INSTALLATION

Order 13-5011. General.

The general rules of this code shall apply to the installation of electrical wiring and equipment in locations classified as Class I under Order 13-5004 of this section except as modified by Orders 13-5012 to 13-5026 inclusive.

Attention is called to the additional requirements set forth in Order 13-5003 for locations where readily ignitible deposits or residues from paints, varnishes, lacquers, or other types of finish may be involved.

Order 13-5012. Transformers and Capacitors.

The installation of transformers and capacitors shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, transformers and capacitors shall conform to the following:

1. Containing a Liquid that Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults, which shall conform to Orders 13-4541 to 13-4548 inclusive, and in addition, (1) there shall be no door or other communicating opening between the vault and the hazardous area, (2) ample ventilation shall be provided for the continuous removal of hazardous gases or vapor, (3) vent openings or ducts shall lead to a safe location outside of buildings, and (4) vent ducts and openings shall be of sufficient area to relieve explosion pressures within the vault, and all portions of vent ducts within the buildings shall be of reinforced concrete construction.

2. Not Containing a Liquid that Will Burn. Transformers and capacitors which do not contain a liquid that will burn shall (1) be installed in vaults conforming to the requirements of sub-paragraph A-1 of this order, or (2) be of explosion-proof type approved for Class I locations.

B. *Class I, Division 2.* In Class I, Division 2 locations, transformers and capacitors shall conform to Orders 13-4521 to 13-4524 inclusive.

Order 13-5013. Meters, Instruments and Relays.

The installation of meters, instruments and relays shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, meters, instruments and relays, including kilowatt-hour meters, instrument transformers and resistors, rectifiers and thermionic tubes, shall be provided with explosion-proof enclosures approved for Class I locations.

It is recommended that such equipment be located outside of the hazardous area where possible.

B. *Class I, Division 2.* In Class I, Division 2 locations, meters, instruments, and relays shall conform to the following:

1. With Make or Break Contacts. Meters, instruments, and relays in which are incorporated contacts for making or breaking current shall conform to paragraph A of this order unless general purpose enclosures are provided and such contacts are (1) immersed in oil, or (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors.

2. Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, and rectifiers, which are used in or in connection with meters, instruments and relays, shall conform to paragraph A of this order, except that enclosures for resistors which operate normally at approximately room temperature may be of general purpose type.

3. Without Make or Break Contacts. Transformer windings, impedance coils, solenoids, and other windings which do not incorporate sliding or make or break contacts shall be provided with enclosures which may be of general purpose type if vents adequate to permit prompt escape of any gases or vapors are provided.

Order 13-5014. Wiring Methods.

Wiring methods shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, rigid metal conduit with threaded explosion-proof joints, and explosion-proof boxes and fittings, shall be the wiring method employed. All threaded joints shall be made up with at least five full threads engaged. Where necessary to employ flexible connections, as at motor terminals, flexible fittings of explosion-proof type approved for the location shall be used.

B. *Class I, Division 2.* In Class I, Division 2 locations, rigid metal conduit or electrical metallic tubing shall be the wiring method employed. Where necessary to employ flexible connections, as at motor terminals, flexible metal conduit shall be used.

Order 13-5015. Sealing.

Seals are provided to prevent the passage of gases, vapors or flames from one portion of the electrical installation to another through the conduit and shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, seals shall be located as follows:

1. In each conduit run entering an enclosure for switches, circuit-breakers, fuses, relays, resistors or other apparatus which may produce arcs, sparks or high temperatures. Seals shall be placed as close as practicable and in no case more than 18 inches from such enclosures.

2. In each conduit run of 2 inch size or larger entering the enclosure or fitting housing terminals, splices or taps, and within 18 inches of such enclosure or fitting.

Where two enclosures for which seals are required under subparagraphs 1 and 2 are connected by a run of conduit not more than 36 inches in length, a single seal would be sufficient if located not more than 18 inches from either enclosure.

3. In each conduit run leaving the Class I, Division 1 hazardous area. The sealing fitting shall be so designed and installed that any gases or vapors which may enter the conduit system, within the Division 1 hazardous area, will not enter or be communicated to the conduit beyond the seal. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the Division 1 hazardous area.

B. *Class I, Division 2.* In Class I, Division 2 locations, seals shall be located as follows:

1. In each conduit run entering an enclosure which is required to be explosion-proof. Seals shall be placed as close as practicable and in no case more than 18 inches from such enclosure. All portions of such conduit run between the seal and the explosion-proof enclosure shall conform to paragraph A, Order 13-5014.

2. In each conduit run passing from the Class I, Division 2 hazardous area into a non-hazardous area. The sealing fitting shall be so designed and installed that any gases or vapors which may enter the conduit system, within the Division 2 hazardous area, will not enter or be communicated to the conduit beyond the seal. Rigid conduit shall be used between the sealing fitting and the point at which the conduit leaves the hazardous area, and a threaded connection shall be used at the sealing fitting. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the hazardous area.

C. *Class I, Divisions 1 and 2.* Where seals are required, they shall conform to the following:

1. Fittings. Enclosures for connections or for equipment shall be provided with approved means for sealing, or sealing fittings approved for Class I locations shall be used.

2. Compound. Sealing compound shall be approved for the purpose, shall not be affected by the surrounding atmosphere or liquids, and shall not have a melting point of less than 93C. (200 F.).

3. Thickness of Compound. In the completed seal, the minimum thickness of the sealing compound shall be not less than the trade size of the conduit, and in no case less than ⅝ inch.

4. Splices and Taps. Splices and taps shall not be made in fittings intended only for sealing with compound, nor shall other fittings in which splices or taps are made be filled with compound.

5. Drainage. Where there is a possibility that water or other condensed vapor may be trapped at any point in the raceway system, approved means shall be provided to prevent accumulation, or to permit periodic draining of such water or condensed vapor.

Order 13-5016. Switches, Circuit-Breakers, Motor Controllers and Fuses.

Switches, circuit-breakers, motor controllers and fuses shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, switches, circuit-breakers, motor controllers and fuses, including push buttons, relays and similar devices, shall be provided with enclosures, and the enclosure in each case together with the enclosed apparatus shall be approved as a complete assembly for use in Class I locations.

B. *Class I, Division 2.* Switches, circuit-breakers, motor controllers and fuses in Class I, Division 2 locations shall conform to the following:

1. Type Required. Circuit-breakers, motor controllers and switches intended to interrupt current in the normal performance of the function for which they are installed shall be provided with explosion-proof enclosures approved for Class I locations, unless general purpose enclosures are provided and (1) the interruption of current occurs within a chamber hermetically sealed against the entrance of gases and vapors, or (2) the current interrupting contacts are oil-immersed and the device is approved for locations of this class and division.

This will include service and branch circuit switches and circuit-breakers; motor controllers, including push-buttons, pilot switches, relays and motor-overload protective devices; and switches and circuit-breakers for the control of lighting and appliance circuits. Oil-immersed circuit-breakers and controllers of ordinary general use type may not confine completely the arc produced in the interruption of heavy overloads, and specific approval for locations of this class and division is therefore necessary.

2. Isolating Switches. Enclosures for disconnecting and isolating switches without fuses and which are not intended to interrupt current may be of general purpose type.

3. Fuses. For the protection of motors, appliances and lamps, except as provided in subparagraph B-4 of this order (1) standard plug or cartridge fuses may be used provided they are placed within explosion-proof enclosures approved for the purpose and for the loca-

tion, or (2) fuses of a type in which the operating element is immersed in oil or other approved liquid, or is enclosed within a chamber hermetically sealed against the entrance of gases and vapors may be used provided they are approved for the purpose and are placed within general purpose enclosures.

4. Fuses or Circuit-Breakers for Overcurrent Protection. When not more than 10 sets of approved enclosed fuses, or not more than 10 circuit-breakers which are not intended to be used as switches for the interruption of current, are installed for branch or feeder circuit protection in any one room, area or section of this class and division, the enclosures for such fuses or circuit-breakers may be of general purpose type, provided the fuses or circuit-breakers are for the protection of circuits or feeders supplying lamps in fixed positions only.

A set of fuses shall be construed to mean a group containing as many fuses as are required to perform a single protective function in a circuit. For example, a group of 3 fuses protecting an ungrounded three-phase circuit, and a single fuse protecting the ungrounded conductor of an identified two-wire single-phase circuit, would each be considered as a set of fuses. Fuses conforming to paragraph B-3 of this order need not be included in counting the 10 sets of fuses permitted in general purpose enclosures.

Order 13-5017. Control Transformers and Resistors.

Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, transformers, impedance coils and resistors, together with any switching mechanism associated with them, shall be provided with explosion-proof enclosures approved for Class I locations.

B. *Class I, Division 2.* In Class I, Division 2 locations, control transformers and resistors shall conform to the following:

1. Switching Mechanisms. Switching mechanisms used in conjunction with transformers, impedance coils and resistors shall conform to Order 13-5016 paragraph B.

2. Enclosures. Enclosures for the windings of transformers or impedance coils may be of general purpose type, but shall be provided with vents adequate to permit prompt escape of gases or vapors that may enter the enclosure.

3. Resistors. Resistors shall be provided with explosion-proof enclosures approved as complete assemblies with the resistors for Class I locations.

Order 13-5018. Motors and Generators.

Motors and generators shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, motors, generators and other rotating electrical machinery shall be of enclosed explosion-proof type approved for Class I locations.

B. *Class I, Division 2.* In Class I, Division 2 locations, motors, generators and other rotating electrical machinery in which are employed sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, either while starting or while running, shall be of enclosed explosion-proof type approved for Class I locations, unless such sliding contacts, switching mechanism or resistance devices are provided with explosion-proof enclosure approved for Class I locations.

This order does not prohibit installation of motors, such as squirrel cage induction motors, without brushes, switching mechanism, etc., in Class I, Division 2 locations.

Order 13-5019. Lighting Fixtures.

Lamps shall be installed in fixtures which shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, lighting fixtures shall conform to the following:

1. Approved Fixtures. Each fixture shall be approved as a complete assembly for locations of this class, and shall be clearly marked to indicate the maximum wattage of lamps for which it is approved. Fixtures intended for portable use shall be specifically approved as complete assemblies for that use.

2. Mechanical Injury. Each fixture shall be protected against mechanical injury by a suitable guard or by location.

3. Pendent Fixtures. Pendent fixtures shall be suspended by and supplied through threaded rigid conduit stems. For stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose and for the location shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

4. Supports. Boxes, box assemblies or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class I locations.

B. *Class I, Division 2.* In Class I, Division 2 locations, lighting fixtures shall conform to the following:

1. Portable Lamps. Portable lamps shall be of the explosion-proof type approved for use in Class I locations.

2. Fixed Lighting. Lighting fixtures for fixed lighting shall be protected from mechanical injury by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or fixtures might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective protective means shall be provided.

3. Pendent Fixtures. Pendent fixtures shall be suspended by threaded rigid conduit stems or by other approved means. For rigid stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose shall be

provided not more than 12 inches from the point of attachment to the supporting box or fitting.

4. Supports. Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose.

5. Switches. Switches which are a part of an assembled fixture or of an individual lampholder shall conform to the requirements of subparagraph B–1, Order 13–5016.

6. Starting Equipment. Starting and control equipment for mercury-vapor and fluorescent lamps shall conform to the requirements of paragraph B. Order 13–5017.

Order 13–5020. Appliances, Fixed and Portable.

Appliances, fixed and portable, shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, appliances, including electrically-heated and motor-driven appliances, shall be approved for Class I locations.

B. *Class I, Division 2.* In Class I, Division 2 locations, appliances, fixed and portable, shall conform to the following:

1. Heaters. Electrically-heated appliances shall be approved for Class I locations.

2. Motors. Motors of motor-driven appliances, if of a type incorporating sliding contacts, centrifugal or other switching mechanisms (including motor over-current devices), or resistance devices, shall be of explosion-proof type approved for Class I locations.

3. Switches, Circuit-breakers, and Fuses. Switches, circuit-breakers and fuses shall conform to paragraph B of Order 13–5016.

Order 13–5021. Flexible Cords, Class I, Divisions 1 and 2.

A flexible cord may be used only for connection between a portable lamp or a portable appliance and the fixed portion of its supply circuit and where used shall (1) be of a type approved for extra hard usage, (2) contain, in addition to the conductors of the circuit, a grounding conductor conforming to Order 13–94003, (3) be connected to terminals or to supply conductors in an approved manner, (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections, and (5) suitable seals shall be provided where the flexible cord enters boxes, fittings or enclosures of explosion-proof type.

Where flexible cords may be exposed to liquids having a deleterious effect on rubber, they should conform also to Order 13–5023.

Order 13–5022. Receptacles and Attachment Plugs, Class I, Divisions 1 and 2.

Receptacles and attachment plugs shall be of polarized type providing for connection to the grounding conductor of the flexible cord, and shall be approved for Class I locations.

Order 13–5023. Conductor Insulation Class I, Divisions 1 and 2.

Where condensed vapors or liquids having a deleterious effect on rubber 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.

Order 13–5024. Signal, Alarm, Remote-control and Communication Systems.

Signal, alarm, remote-control and communication systems shall conform to the following:

A. *Class I, Division 1.* In Class I, Division 1 locations, all apparatus and equipment of signalling, alarm, remote-control and communication systems, irrespective of voltage, shall be approved for Class I locations, and all wiring shall conform to paragraph A, Order 13–5014, and paragraphs A and C, Order 13–5015.

B. *Class I, Division 2.* In Class I, Division 2 locations, signal, alarm, remote-control and communication systems shall conform to the following:

1. Contacts. Switches and circuit-breakers, and make and break contacts of push buttons, relays, and alarm bells or horns, shall have explosion-proof enclosures approved for Class I locations, unless general purpose enclosures are provided and current interrupting contacts are (1) immersed in oil, or (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors.

2. Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes and rectifiers shall conform to paragraph A of this order except that enclosures for resistors which operate normally at approximately room temperature may be of general purpose type.

3. Protectors. Enclosures which may be of general purpose type shall be provided for lightning protective devices and for fuses.

Order 13–5025. Live Parts, Class I, Divisions 1 and 2.

There shall be no exposed live parts.

Order 13–5026. Grounding, Class I, Divisions 1 and 2.

Wiring and equipment shall be grounded in conformity with the following:

A. *Exposed Parts.* The exposed non-current-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable lamps or appliances, lighting fixtures, cabinets, cases, and conduit, shall be grounded as specified in Section 13–250 of this code.

B. *Bonding.* The locknut-bushing and double-locknut types of contacts shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings or other approved means shall be used. If flexible conduit is used as permitted in subparagraph B of Order 13–5014, bonding jumpers with proper fittings shall be provided around such conduit.

C. *Lightning Protection.* Each ungrounded service conductor of a wiring system in a Class I location, when supplied from an ungrounded overhead electrical supply system in an area where lightning dis-

turbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

D. *Grounded Service Conductor Bonded to Raceway.* Wiring in a Class I location, when supplied from a grounded alternating current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

E. *Transformer Ground Bonded to Raceway.* Wiring in a Class I location, when supplied from a grounded alternating current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the raceway system at the service entrance. The metallic connection shall have a current carrying capacity not less than ⅛ that of the service conductors, and shall in no case be smaller than No. 10 if of soft copper, or No. 12 if of medium or hard-drawn copper.

F. *Multiple Grounds.* Where, in the application of Order 13-2521, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in paragraphs D and E of this order shall not be abandoned while any other grounding connection remains connected to the supply system.

CLASS II—INSTALLATION

Order 13-5051. General.

The general orders of this code shall apply to the installation of electrical wiring and apparatus in locations classified as Class II under Order 13-5005 of this section except as modified by Orders 13-5052 to 13-5066 inclusive.

Order 13-5052. Transformers and Capacitors.

The installation of transformers and capacitors shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, transformers and capacitors shall conform to the following:

1. Containing a Liquid that Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults conforming to Orders 13-4541 to 13-4548 inclusive, and in addition (1) door or other openings communicating with the hazardous area shall have self-closing fire doors on both sides of the wall, and the doors shall be carefully fitted and provided with suitable seals (such as weather stripping) to minimize the entrance of dust into the vault, (2) vent openings and ducts shall communicate only with the outside air, and (3) suitable pressure-relief openings communicating with the outside air shall be provided.

2. Not Containing a Liquid that Will Burn. Transformers and capacitors which do not contain a liquid that will burn shall (1) be installed in vaults conforming to Orders 13-4541 to 13-4548 inclusive, or (2) be of approved dust-tight construction with dust-tight terminal enclosures.

3. Metal Dusts. No transformer or capacitor shall be installed in a location where dust from the production of magnesium, aluminum or aluminum bronze powders may be present.

B. *Class II, Division 2.* In Class II, Division 2 locations, transformers and capacitors shall conform to the following:

1. Containing a Liquid that Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed in vaults conforming to Orders 13-4541 to 13-4548 inclusive.

2. Containing Askarel. Transformers containing askarel and rated in excess of 25 kva shall (1) be provided with pressure-relief vents, (2) be provided with means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents shall be connected to a chimney or flue which will carry such gases outside the building and (3) have an air space of not less than 6 inches between the transformer cases and any adjacent combustible material.

3. Dry-Type Transformers. Dry-type transformers shall be installed in vaults or shall (1) have their windings and terminal connections enclosed in tight metal housings without ventilating or other openings, and (2) operate at voltages not exceeding 600 volts.

Order 13-5053. Surge Protection, Class II, Divisions 1 and 2.

In geographical locations where lightning disturbances are prevalent, wiring systems in Class II locations shall, if supplied from overhead supply systems, be suitably protected against high-voltage surges. This protection shall include suitable lightning protective devices, interconnection of all grounds, and surge-protective capacitors.

Suitable lightning protective devices should include primary devices, and also secondary devices if overhead secondary lines exceed 300 feet in length or if secondary is ungrounded.

Interconnection of all grounds should include grounds for primary and secondary lightning protective devices, secondary system grounds if any, and grounds of conduit and equipment of the interior wiring system.

Surge protective capacitors should be of a type especially designed for the duty, should be connected to each ungrounded service conductor, and should be grounded to the interior conduit system. Capacitors should be protected by 30-ampere fuses of suitable type and voltage rating, or by automatic circuit-breakers of suitable type and rating and should be connected to the supply conductors on the supply side of the service disconnecting means.

Order 13-5054. Wiring Methods.

Wiring methods shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, wiring shall be in rigid metal conduit with threaded boxes and fittings.

1. Fittings and Boxes. Fittings and boxes shall be provided with threaded bosses for conduit connection, shall have close fitting covers, and shall have no openings (such as holes for attaching screws) through which sparks or burning material might escape. Fittings and boxes in which taps, joints or terminal connections are made, or which are used in locations where dusts are of an electrically-conducting nature shall be approved for Class II locations.

2. Flexible Connections. Where necessary to employ flexible connections, dust-tight flexible connectors, flexible metal conduit, or flexible cord approved for extra hard usage and provided with bushed fittings shall be used, except that where dusts are of an electrically-conducting nature, flexible metal conduit shall not be used, and flexible cords shall be provided with dust-tight seals at both ends. Where flexible connections are subject to oil or other corrosive conditions, the conductors shall be of a type approved for the condition. An additional conductor for grounding shall be provided in the flexible cord unless other acceptable means of grounding is provided.

B. *Class II, Division 2.* In Class II, Division 2 locations, wiring shall be in rigid metal conduit or electrical metallic tubing.

1. Fittings and Boxes. Fittings and boxes in which taps, joints or terminal connections are made shall (1) be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

2. Flexible Connections. Where flexible connections are necessary the provisions of sub-paragraph A–2 of this order shall apply.

Order 13–5055. Sealing, Class II, Divisions 1 and 2.

Where a raceway provides communication between a non-dust-tight fitting or enclosure and one which is required to be dust-tight, suitable means shall be provided to prevent the entrance of dust into the dust-tight enclosure through the raceway. This means may be (1) a permanent and effective seal, (2) a horizontal section not less than 10 feet long in the raceway, or (3) a vertical section of raceway not less than 5 feet long and extending downward from the dust-tight enclosure.

Order 13–5056. Switches, Circuit-Breakers, Motor Controllers, and Fuses.

Switches, circuit-breakers, motor controllers and fuses shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, switches, circuit-breakers, motor controllers and fuses shall conform to the following:

1. Type Required. Switches, circuit-breakers, motor controllers and fuses, including push buttons, relays and similar devices, which are intended to interrupt current in the normal performance of the function for which they are installed, or which are installed where dusts of an electrically-conducting nature may be present, shall be provided with dust-tight enclosures approved for Class II locations.

This will include service and branch circuit fuses, switches and circuit-breakers, motor controllers (including push buttons, pilot switches, relays, and motor overload protective devices), and switches, fuses and circuit-breakers for the control and protection of lighting and appliance circuits.

2. Isolating Switches. Disconnecting and isolating switches containing no fuses and not intended to interrupt current, and which are not installed where dusts may be of an electrically conducting nature, shall be provided with tight metal enclosures which shall (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 Dust. In locations where dust from the production of magnesium, aluminum or aluminum bronze powders may be present, fuses, switches, motor controllers and circuit-breakers shall have dust-tight enclosures specifically approved for such locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, enclosures for fuses, switches, circuit-breakers and motor controllers including push buttons, relays and similar devices, shall conform to the requirements of subparagraph A–2 of this order.

Order 13–5057. Control Transformers and Resistors.

Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, control transformers, impedance coils and resistors, and any overcurrent devices or switching mechanisms associated with them shall have dust-tight enclosures approved for Class II locations. No control transformer, impedance coil or resistor shall be installed in a location where dust from the production of magnesium, aluminum or aluminum bronze powders may be present unless provided with a dust-tight enclosure specifically approved for such locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, transformers and resistors shall conform to the following:

1. Switching Mechanisms. Switching mechanisms, including overcurrent devices associated with control transformers, impedance coils and resistors shall be provided with enclosures conforming to subparagraph A–2 of Order 13–5056.

2. Enclosures. Control transformers and impedance coils shall be provided with tight metal housings without ventilating openings.

3. Resistors. Resistors and resistance devices, except heating elements of overcurrent devices, shall have dust-tight enclosures approved for Class II locations.

Order 13–5058. Motors and Generators.

Motors and generators shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, motors, generators and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled, and shall be approved for Class II locations. Motors, generators or other rotating electrical machinery shall not be installed in locations where dust from the production of magnesium, aluminum or aluminum bronze powders may be present unless such machines are totally-enclosed, or totally-enclosed fan cooled, and specifically approved for such locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, motors, generators and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled, except that in locations where, in the judgment of the code enforcing authority, only moderate accumulations of non-conducting non-abrasive dust are likely to occur, and where the equipment is readily accessible for routine cleaning and maintenance self-cleaning textile motors of the squirrel-cage type, standard open type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, or standard open type machines having such contacts, switching mechanisms or resistance devices enclosed within tight metal housings without ventilating or other openings, may be installed. Motors, generators or other rotating electrical machinery of protected or splashproof type shall not be installed in such locations.

Order 13–5059. Ventilating Piping.

Vent pipes for motors, generators or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall be of metal not lighter than No. 24 USS gauge, or of equally substantial non-combustible material, and shall (1) lead directly to a source of clean air outside of buildings, (2) be screened at the outer ends to prevent the entrance of small animals or birds, (3) be protected against mechanical damage and against rusting or other corrosive influences. In addition, vent pipes shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, vent pipes, including their connections to motors or to the dust-tight enclosures for other equipment, or apparatus, shall be dust-tight throughout their length. For metal pipes, seams and joints shall be (1) riveted (or bolted) and soldered, (2) welded, or (3) rendered dust-tight by some other equally effective means.

B. *Class II, Division 2.* In Class II, Division 2 locations, vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of dust into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite dust accumulations or combustible material

in the vicinity. For metal pipes, lock seams and riveted or welded joints may be used, and tight-fitting slip joints may be used where some flexibility is necessary as at connections to motors.

Order 13–5060. Appliances, Fixed and Portable.

Appliances, fixed and portable, shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, appliances, including electrically-heated and motor-driven appliances, shall be approved for Class II locations. Fixed or portable appliances shall not be installed or used in locations where dust from magnesium, aluminum or aluminum bronze powders may be present unless such appliances are dust-tight and are specifically approved for such locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, appliances, fixed and portable, shall conform to the following:

1. Heaters. Electrically-heated appliances shall be approved for Class II locations.

2. Motors. Motors of motor-driven appliances shall conform to paragraph B of Order 13–5058.

3. Switches. Circuit-breakers and Fuses. Enclosures for switches, circuit-breakers, and fuses shall conform to sub-paragraph A–2 of Order 13–5056.

4. Transformers, Impedance Coils and Resistors. Transformers, impedance coils and resistors shall conform to paragraph B of Order 13–5057.

Where there is a possibility that a portable appliance may be used in both Division 1 or Division 2 locations of this class, such appliance should conform to the requirements for Division 1 locations.

Order 13–5061. Lighting Fixtures.

Lamps shall be installed in fixtures which shall conform to the following:

A. *Class II, Division 1.* In Class II, Division 1 locations, lighting fixtures for fixed and portable lighting shall conform to the following:

1. Approved Fixtures. Each fixture shall be approved for Class II locations, and shall be clearly marked to indicate the maximum wattage of the lamp for which it is approved. In locations where dust from magnesium, aluminum or aluminum bronze powders may be present, fixtures for fixed or portable lighting, and all auxiliary equipment, shall be dust-tight, and shall be specifically approved for such locations.

2. Mechanical Injury. Each fixture shall be protected against mechanical injury by a suitable guard or by location.

3. Pendent Fixtures. Pendent fixtures shall be suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means. For rigid stems longer than 12 inches permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose and for the location shall be provided not

more than 12 inches from the point of attachment to the supporting box or fitting. Where wiring between an outlet box or fitting and a pendent fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used, and suitable seals shall be provided where the cord enters the fixture and the outlet box or fitting. Flexible cord shall not serve as the supporting means for a fixture.

4. Supports. Boxes, box assemblies or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class II locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, lighting fixtures shall conform to the following:

1. Portable Lamps. Portable lamps shall be dust-tight, and 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 shall provide enclosures for lamps and lampholders. Enclosures shall be designed to minimize the deposit of dust on lamps and to prevent the escape of sparks, burning material or hot metal.

3. Mechanical Injury. Lighting fixtures for fixed lighting shall be protected from mechanical injury by suitable guards or by location.

4. Pendent Fixtures. Pendent fixtures shall be suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means. For rigid stems longer than 12 inches permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting. When wiring between an outlet box or fitting and a pendent fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used. Flexible cord shall not serve as the supporting means for a fixture.

5. Supports. Boxes, box assemblies and fittings used for the support of lighting fixtures shall be approved for that purpose.

6. Electric Discharge Lamps. Starting and control equipment for mercury vapor and fluorescent lamps shall conform to the requirement of paragraph B of Order 13-5057.

Order 13-5062. Flexible Cords, Class II, Divisions 1 and 2.

Flexible cords used in Class II locations shall (1) be of a type approved for extra hard usage, (2) contain, in addition to the conductors of the circuit, a grounding conductor conforming to Order 13-94003, (3) be connected to terminals or to supply conductors in an approved manner, (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections, and (5) be provided with suitable seals to prevent the entrance of dust where the flexible cord enters boxes or fittings which are required to be dust-tight.

Order 13-5063. Receptacles and Attachment Plugs.

A. *Class II, Division 1.* In Class II, Division 1 locations, receptacles and attachment plugs shall be of polarized type providing for connection to the grounding conductor of the flexible cord, and shall be approved for Class II locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, receptacles and attachment plugs shall be of polarized type providing for connection to the grounding conductor of the flexible cord, and shall be so designed that connection to the supply circuit cannot be made or broken while live parts are exposed.

Order 13-5064. Signal, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systems.

Signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to the following:

Refer to Section 13-800 for orders governing the installation of communication circuits as defined in Order 1020.

A. *Class II, Division 1.* In Class II, Division 1 locations, signal, alarm, remote-control and local loudspeaker intercommunication systems shall conform to the following:

1. Wiring Method. Where accidental damage or break-down of insulation might cause arcs, sparks or high temperatures, rigid metal conduit or electrical metallic tubing shall be the wiring method employed, and the number of conductors in a raceway shall be limited only by the requirement that the cross-sectional area of all conductors shall not exceed 40 per cent of the area of the raceway.

2. Contacts. Switches, circuit-breakers, relays, contactors and fuses which may interrupt other than voice currents, and current-breaking contacts for bells, horns, howlers, sirens and other devices in which sparks or arcs may be produced, shall be provided with dust-tight enclosures approved for the location, unless current-breaking contacts are immersed in oil, or unless the interruption of current occurs within a chamber sealed against the entrance of dust, in which case enclosures may be of general purpose type.

3. Resistors and Similar Equipment. Resistors, transformers and choke coils which may carry other than voice currents, and rectifiers, thermionic tubes, and other heat generating equipment or apparatus shall be provided with dust-tight enclosures approved for Class II locations.

4. Rotating Machinery. Motors, generators and other rotating electrical machinery shall conform to paragraph A of Order 13-5058.

5. Electrical Conducting Dusts. Where dusts are of an electrically-conducting nature, all wiring and equipment shall be dust-tight.

6. Metal Dusts. Where dust from magnesium, aluminum or aluminum bronze powders may be present, all apparatus and equipment shall be dust-tight, and shall be specifically approved for such locations.

B. *Class II, Division 2.* In Class II, Division 2 locations, signal, alarm, remote-control and local loudspeaker intercommunication systems shall conform to the following:

1. Contacts. Enclosures shall conform to sub-paragraph A–2 of this order or shall be in tight metal enclosures having telescoping or tight fitting covers, and having no openings through which, after installation, sparks or burning material might escape.

2. Transformers and Similar Equipment. The windings and terminal connections of transformers and choke coils shall be provided with tight metal enclosures without ventilating openings.

3. Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, and rectifiers shall conform to sub-paragraph A–3 of this order except that enclosures for resistors which operate at approximately room temperature may be of general purpose type.

Order 13–5065. Live Parts, Class II, Divisions 1 and 2.

There shall be no exposed live parts.

Order 13–5066. Grounding, Class II, Divisions 1 and 2.

Wiring and equipment shall be grounded in conformity with the following:

A. *Exposed Parts.* The exposed non-current-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable lamps or appliances, lighting fixtures, cabinets, cases, and conduit, shall be grounded as specified in Section 13–250 of this code.

B. *Bonding.* The locknut-bushing and double-locknut types of contact shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings or other approved means shall be used. If flexible conduit is used as permitted in Order 13–5054, bonding jumpers with proper fittings shall be provided around such conduit.

C. *Lightning Protection.* Each ungrounded service conductor of a wiring system in a Class II location, when supplied from an ungrounded overhead electrical supply system in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

D. *Grounded Service Conductor Bonded to Raceway.* Wiring in a Class II location, when supplied from a grounded alternating-current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

E. *Transformer Ground Bonded to Raceway.* Wiring in a Class II location, when supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the raceway system at the service entrance. The metallic connection shall have a current-carrying capacity not less than ⅓ that of the service conductors, and shall in no case be smaller than No. 10 if of soft copper, or No. 12 if of medium or hard-drawn copper.

F. *Multiple Grounds.* Where, in the application of Order 13–2521, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in paragraphs D or E of this order shall not be abandoned while any other grounding connection remains connected to the supply system.

CLASS III—INSTALLATION

Order 13–5071. General.

The general rules of this code shall apply to the installation of electrical wiring and apparatus in locations classified as Class III under Order 13–5006 of this section except as modified by Orders 13–5072 to 13–5087 inclusive.

Order 13–5072. Transformers and Capacitors, Class III, Divisions 1 and 2.

Transformers and capacitors shall conform to paragraph B of Order 13–5052.

Order 13–5073. Wiring Methods.

Wiring methods shall conform to the following:

A. *Class III, Division 1.* In Class III, Division 1 locations, rigid metal conduit shall be the wiring method employed.

1. Boxes and Fittings. Fittings and boxes in which taps, joints or terminal connections are made shall (1) be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

2. Flexible Connections. Where flexible connections are necessary the provisions of sub-paragraph A–2 of Order 13–5054 shall apply.

B. *Class III, Division 2.* In Class III, Division 2 locations, the wiring method shall conform to paragraph A of this order, except that in sections, compartments or areas used solely for storage and containing no machinery, open wiring on insulators may be employed if installed to conform to Section 13–320, but only on condition that protection as required by Order 13–3212 be provided where conductors are not run in roof spaces, and well out of reach of sources of mechanical injury.

Order 13–5074. Switches, Circuit-Breakers, Motor Controllers and Fuses, Class III, Divisions 1 and 2.

Switches, circuit-breakers, motor controllers and fuses, including pushbuttons, relays and similar devices, shall be provided with tight

metal enclosures 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.

Order 13–5075. Control Transformers and Resistors, Class III, Divisions 1 and 2.

Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances, shall conform to paragraph A of Order 13–5057.

Order 13–5076. Motors and Generators.

Motors and generators shall conform to the following:

A. *Class III, Divison 1.* In Class III, Division 1 locations, motors, generators, and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled, except that in locations where, in the judgment of the code enforcing authority, only moderate accumulations of lint and flyings will be likely to collect on, in, or in the vicinity of a rotating electrical machine, and where such machine is readily accessible for routine cleaning and maintenance, self-cleaning textile motors of the squirrel-cage type, standard open type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overload devices), or standard open type machines having such contacts, switching mechanisms or resistance devices enclosed within tight metal housings without ventilating or other openings, may be installed.

B. *Class III, Division 2.* In Class III, Division 2 locations, motors, generators, and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled.

C. *Protected Type, Class III, Divisions 1 and 2.* Motors, generators or other rotating electrical machinery of the protected or splash-proof type shall not be installed in Class III locations.

Order 13–5077. Ventilating Piping, Class III, Divisions 1 and 2.

Vent pipes for motors, generators or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall be of metal not lighter than No. 24 USS gauge, or of equally substantial non-combustible material, and shall (1) lead directly to a source of clean air outside of buildings, (2) be screened at the outer ends to prevent the entrance of small animals or birds, (3) be protected against mechanical damage and against rusting or other corrosive influences, and (4) vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of fibers or flyings into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite accumulations of fibers or flyings or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints may be used, and tight fitting slip joints may be used where some flexibility is necessary as at connections to motors.

Order 13–5078. Appliances, Fixed and Portable, Class III, Divisions 1 and 2.

Appliances shall conform to the following:

A. *Heaters.* Electrically-heated appliances shall be provided with dust-tight enclosures, and shall be approved for Class III locations.

B. *Motors.* Motors of motor-driven appliances shall conform to paragraph B of Order 13–5076. Appliances which may be readily moved from one location to another should conform to requirements for the most hazardous location.

C. *Switches, Circuit-breakers, Motor Controllers and Fuses.* Switches, circuit-breakers, motor controllers and fuses shall conform to paragraph A of Order 13–5056.

Order 13–5079. Lighting Fixtures, Class III, Divisions 1 and 2.

Lamps shall be installed in fixtures which shall conform to the following:

A. *Construction.* Each fixture shall be of dust-tight type so designed that in the event of burnout of lamp or lampholder, no spark or hot metal can escape from the fixture. Unless each fixture is so constructed that it will not accept a lamp of larger wattage than that for which it is designed, it shall be clearly marked to indicate the maximum wattage of lamp that should be used.

B. *Mechanical Injury.* A fixture which may be exposed to mechanical injury shall be protected by a suitable guard.

C. *Pendent Fixtures.* Pendent fixtures shall be suspended by stems of threaded rigid conduit or threaded metal tubing of equivalent thickness. For stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

D. *Supports.* Boxes, box assemblies or fittings used for the support of lighting fixtures shall be of a type approved for the purpose.

E. *Portable Lamps.* Portable lamps shall be dust-tight, and shall be protected with substantial guards. Lampholders shall be of unswitched type with no exposed metal parts. Unless the portable lamp is so constructed that it will not accept a lamp of larger wattage than that for which it is designed, it shall be clearly marked to indicate the maximum wattage of lamp that should be used.

Order 13–5080. Flexible Cords, Class III, Divisions 1 and 2.

Flexible cords shall conform to Order 13–5062.

Order 13–5081. Receptacles and Attachment Plugs, Class III, Divisions 1 and 2.

Receptacles and attachment plugs shall conform to paragraph B of Order 13–5063.

Order 13–5082. Signal, Alarm, Remote-Control and Local Loud-Speaker Intercommunication Systems, Class III, Divisions 1 and 2.

Signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to paragraph A of Order 13–5064.

Order 13–5083. Electric Cranes, Class III, Divisions 1 and 2.

Electric cranes may be installed under the following conditions: Electric cranes operating over combustible fibers shall not be operated on a system with a grounded conductor. Feeders for electric cranes shall be furnished with a recording ground detector, and protected by a relay which will automatically open the feeder circuit-breaker in the event of the insulation of the system falling below 1000 ohms. Bare conductors for cranes operating in rooms used for the storage of combustible fibers shall be protected by barriers so arranged as to prevent any escape of sparks or hot particles, and the moving current collectors shall be so designed as to minimize sparking at sliding contacts.

It is recommended that where the distance of travel permits, current to the crane be supplied through flexible cord approved for extra hard usage and equipped with approved type of reel or take-up device.

Order 13–5084. Electric Trucks.

Electric trucks shall conform to the following:

A. *Class III, Divison 1.* Electric trucks shall not be used in Class III, Division 1 locations.

B. *Class III, Division 2.* In Class III, Division 2 locations, electric trucks shall have wheels equipped with rubber tires or made of non-conducting material. Electric trucks shall have their batteries charged only in rooms meeting the requirements of Order 13–5085.

Order 13–5085. Storage-Battery Charging Equipment, Class III, Divisions 1 and 2.

Storage-battery charging equipment shall be located in separate rooms built or lined with substantial non-combustible materials so constructed as to adequately exclude flyings or lint, and shall be well ventilated.

Order 13–5086. Live Parts, Class III, Divisions 1 and 2.

There shall be no exposed live parts except as provided in Order 13–5083.

Order 13–5087. Grounding, Class III, Divisions 1 and 2.

Wiring and equipment shall be grounded in conformity with Order 13–5066.

SECTION 13–510. GARAGES AND SIMILAR OCCUPANCIES

GENERAL

Order 13–5101. Scope.

The provisions of this section shall apply to airplane hangars, garages, commercial garages, gasoline service stations, and other locations where gasoline or other highly volatile motor fuel is stored in vehicles, dispensed, or where service and repair operations are carried on with this type of equipment. Where service or repair operations involving more hazardous conditions are carried on, the provisions of other applicable sections of this code shall apply. The provisions of this section shall not apply to any portion of a building which is suitably cut off from the garage and not used for the above purpose.

Order 13–5102. General.

This section provides additional required precautions in installation of electric equipment where volatile or flammable liquids are handled or used as fuel or power in self-propelled vehicles.

Where reference is made in this section to a level of 4 feet above the floor, it shall be construed to mean each floor at or above grade level. In the case of floors below grade level, the measurement shall begin not at the floor but at the bottom of outside doors or other openings at or above grade level.

Order 13–5103. Types of Equipment.

Equipment which tends to produce arcs or sparks, such as cutouts, switches, receptacles, lampholders, charging panels, generators, motors, or other equipment having make or break or sliding contacts, when located within 4 feet of the floor shall be of a type approved for use in Class I, Division 2 locations as defined in Section 13–500 of this code. Equipment which may produce temperatures which may cause ignition of such fuel or gas, when located within 4 feet of the floor, shall be of a type approved for use in Class I, Division 2 locations as defined in Section 13–500 of this code. Where such equipment is located above the 4-foot level, it shall be of the totally-enclosed type or shall have all openings guarded or screened so as to prevent the falling of hot metal particles in case an arc occurs.

A. *Show Rooms and Switchboard Rooms.* Equipment located in a suitable room or enclosure provided for the purpose or in a show room separated from the garage proper by a partition which is reasonably tight up to the 4 foot level as defined in Order 13–5102, need not conform to the requirements of this order.

Order 13–5104. Polarization of Pendants and Portables.

If the wiring system is identified as provided in Section 13–200, flexible cords shall be identified and the identified conductor shall be connected to the screw shell of all lampholders on portables or pend-

ants. Receptacles, attachment plugs, connectors, and similar devices shall be of the polarized type.

Order 13–5105. Connectors.

Cords used for the connection of portable appliances shall carry the male end of a polarity-type pin-plug connector, or equivalent, the female end being of such design or so hung that the connector will break apart readily at any position of the cable. The connector shall be kept at least 4 feet above the floor. A take-up reel or equivalent approved device may be used.

Order 13–5106. Cord for Pendants.

For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used.

Order 13–5107. Cord for Portables.

For connection of portable lamps, motors or other appliances, flexible cord suitable for the type of service and approved for extra hard usage shall be used.

Order 13–5108. Lampholders and Guards for Portables.

Portable lamps shall be equipped with handle, lampholder, a hook and substantial lamp guard attached to the lampholder or handle. All exterior surfaces which might come in contact with other objects shall be of non-conducting material, or shall be effectively protected with insulation. Lampholders shall be of the unswitched type and shall not provide means for plug-in of attachment cord caps. Lampholders shall be of the molded composition or other type approved for the purpose. Metalshell, lined lampholders, either of the switched or unswitched type, shall not be used.

Order 13–5109. Portable Lampholders Used in Pits.

Where portable lamps are used in pits or other places in which gasoline fumes are liable to settle, they shall be of a type approved for use in Class I, Division 2 locations as defined in Section 13–500 of this code.

Order 13–5110. Lampholders.

Where practicable, lampholders shall have non-conducting outer casings.

Order 13–5111. Live Parts.

Live parts of equipment shall be guarded to prevent accidental contact.

Order 13–5112. Grounding.

All metallic conductor enclosures and the exposed metal parts of fixed equipment, except pendent or portable lamps operating on grounded systems of not more than 150 volts to ground, shall be grounded in the manner prescribed in Section 13–250.

RESIDENTIAL STORAGE GARAGES

Order 13–5121. Residential Storage Garages—Six Cars or Less.

All wiring located 4 feet or more above the floor may be of any type covered by the provisions of Chapter 3 of this code.

COMMERCIAL GARAGES AND AIRPLANE HANGARS

Order 13–5131. Commercial Garages and Airplane Hangars.

Only metallic raceway or armored cable systems may be used. Cellular metal floor raceways may be used only for supplying ceiling outlets or extensions to the area below the floor but not above. No electric conductor shall be installed in any cell or header which contains a pipe for steam, water, air, gas, drainage, or other service than electrical. All wiring which is used in connection with equipment located below the 4 foot level shall be installed to conform to Section 13–500, Class I, Division 2, of this code.

Order 13–5132. Battery-Charging Equipment.

Battery chargers and control equipment shall be located at least 4 feet above the floor. Tables, racks, trays, and wiring methods shall in addition conform to the provisions of Section 13–480.

Order 13–5133. Electric Vehicle Charging.

Equipment for electric vehicle charging shall conform to the following:

A. *Type of Cord.* Flexible cords used for charging purposes shall be suitable for the type of service and approved for extra hard usage.

B. *Connector Rating.* Connectors shall be at least 50 amperes capacity.

C. *Connectors.* Connectors shall be so designed and so installed that they will break apart readily at any position of the charging cable. Live parts shall be guarded from accidental contact. Where plugs for direct connection to vehicles are suspended from overhead, the cord shall be arranged so that the lowest point of sag is at least 6 inches from the floor. Where the vehicle is equipped with an approved plug which will readily pull apart and is arranged to automatically pull both cord and plug out of the way so as not to be subject to mechanical injury, no additional connector need be placed in the cable or at the outlet.

GASOLINE DISPENSING AND SERVICE STATIONS

Order 13–5141. Gasoline Dispensing and Motor-Vehicle Service Station.

Equipment for gasoline dispensing and motor-vehicle service stations shall conform to Orders 13–5141, 13–5142 and 13–5143.

A. *Lubritorium Service and Repair Rooms.* All wiring and equipment below 4 feet of the main level shall comply with the provisions

of Class I, Division 2, of Section 13-500 of this code. All other wiring shall conform to the provisions of Order 13-5131.

B. *Other Locations.* Office, salesroom, compressor rooms, and other similar areas which are suitably cut off from the lubritorium, service and repair rooms, shall be wired to comply with the provisions of Chapter 3 of this code.

Order 13-5142. Dispensing Island.

The wiring in a dispensing island shall conform to the following:

A. All wiring and equipment less than 4 feet above the car drive level shall conform to the provisions of Section 13-500 for Class I, Division 1 locations.

B. All conduits shall be sealed as they enter dispensing pumps or other equipment on the island.

C. Conductors in conduits entering or leaving dispensing pumps, when covered with a rubber compound or other compound upon which the dispensed liquid will have a deleterious effect, must be sheathed with a suitable material such as lead.

D. All circuits supplying dispensing pumps shall be controlled by a switch having a disconnecting pole in each conductor.

Order 13-5143. Pole Standards.

In an outside location, all wiring and equipment less than 4 feet above the adjacent ground or apron level, and less than 20 feet horizontally from any dispensing island or pump, tank fill-pipe, or tank vent-pipe, shall conform to the provisions of Section 13-500 for Class I, Division 2 locations, unless the authority enforcing the Code specifies conformance to requirements for Class I, Division 1 locations. Approved seals shall be provided in all conduit runs leaving the defined area.

BULK-STORAGE PLANTS

Order 13-5151. Bulk-Storage Plants.

A. Equipment for bulk-storage plants handling gasoline or other volatile liquids with similar hazards, shall conform to Orders 13-5152 to 13-5157 inclusive.

B. Electric lines operating at more than 300 volts to ground shall not pass over flammable liquids storage tanks and shall be kept at least 15 feet horizontally from such tanks. When the voltage is below 300, a clearance both vertically and horizontally of not less than 8 feet, shall be maintained.

Order 13-5152. Equipment.

Motors, controllers, wiring, and equipment used as part of the bulk plant shall comply with the provisions of Section 13-500 of this code, unless the authority enforcing the Code judges a specific area or location to be non-hazardous.

Order 13-5153. Underground Wiring.

Wiring located in not less than 2 feet of earth may be in rigid conduit, or an approved lead-covered cable assembly, provided that rigid conduit is used where these cables leave the earth extending from a point of lowest buried cable level to the equipment so served.

Order 13-5154. Pole Standards.

All outside wiring and equipment more than 15 feet above adjacent ground level shall conform to the requirements of Chapter 3, unless the authority enforcing the Code specifies conformance to the provisions of Section 13-500. Wiring and equipment below that level shall conform to the requirements of Section 13-500 unless the location is judged to be non-hazardous by the authority enforcing the Code.

Order 13-5155. Platforms.

All wiring and equipment located on filling platforms shall comply with the provisions of Section 13-500 of this code.

Order 13-5156. Storage and Repair Garages for Tank Trucks.

All wiring shall conform to the provisions of Class I, Division 2, of Section 13-500 of this code, unless the authority enforcing the Code specifies conformance to requirements for Class I, Division 1 locations.

Order 13-5157. Office Buildings.

In office buildings, boiler rooms, and other building units isolated by location and in which no gasoline or container are used or stored, the wiring shall comply with the provisions of Chapter 3 of this code.

SECTION 13-520. THEATERS, INCLUDING MOTION PICTURE HOUSES

Order 13-5201. Scope.

The requirements of this section shall apply to all buildings, or part of a building, designed, intended, or used for dramatic, operatic, motion picture or other shows.

Note. The Wisconsin State Building Code contains definitions covering theaters and assembly halls.

Order 13-5202. Emergency Lighting.

An emergency lighting system shall be provided where the seating capacity of the auditorium exceeds 100 persons. When electricity is used for emergency lighting, this system shall conform to the requirements of Section 13-700.

Order 13-5203. Motion Picture Projectors.

Motion picture projectors shall comply with Section 13-540.

Order 13-5204. Sound Reproduction.

Sound reproducing equipment shall comply with Section 13-640.

INSTALLATION

Order 13–5211. Wiring Method.

The wiring method shall be metal raceways, except (1) as provided in Sections 13–640 and 13–800; (2) when the auditorium has a seating capacity of 100 persons or less, armored cable as provided in Section 13–334 may be used, or for concealed work, concealed knob-and-tube work or non-metallic sheathed cable as provided in Sections 13–324 and 13–336 may also be used. Portable cables may be used only where fixed wiring methods are impracticable.

Order 13–5212. Number of Conductors in Raceway.

The number of conductors permitted in any metal conduit or electrical metallic tubing for border or stage pocket circuits or for remote-control conductors shall not exceed that shown in Table 9 of Chapter 10. The number of conductors for border or stage pocket circuits or for remote-control conductors in auxiliary gutters or metal wireways shall have a total cross sectional area not exceeding 20 per cent of the cross sectional area of the gutter or wireway.

Order 13–5213. Conductor Insulation.

Foot, border, proscenium, or portable strip light fixtures shall be wired with conductors having insulation suitable for the temperatures at which the conductors will be operated and not less than 125C (257F). See the table in Order 13–3102.

STAGE SWITCHBOARD

Order 13–5221. Dead Front.

Stage switchboards shall be of the dead-front type.

Order 13–5222. Guarding.

Stage switchboards having exposed live parts on the back of such boards shall be enclosed by the building walls, wire mesh grills, or by other approved methods. The entrance to this enclosure shall be by means of a self-closing door.

Order 13–5223. Control and Overcurrent Protection of Receptacle Circuits.

Means shall be provided at the stage switchboard for the control and individual overcurrent protection of branch circuits to stage and gallery receptacles used for portable stage equipment.

Order 13–5224. Metal Hood.

Stage switchboard shall be provided with a metal hood extending the full length of the board to protect all equipment on the board from falling objects, unless the switchboard is recessed in the building construction or is of the completely enclosed, dead-front and dead-rear type.

Order 13–5225. Dimmers.

Dimmers shall conform to the following:

A. *Disconnection from Supply.* If dimmers are installed in ungrounded conductors, each dimmer shall have overcurrent protection not greater than 125 per cent of the dimmer rating, and shall be disconnected from all ungrounded conductors when the master or individual switch or circuit-breaker supplying such dimmer is in the open position.

B. *Resistance or Reactor Type Dimmers.* Resistance or series reactor type dimmers may be placed in either leg of the circuit. If designed to open either the supply circuit to the dimmer or the circuit controlled by it, the dimmer shall then comply with Order 13–3801.

It is recommended that resistance or reactor type dimmers be placed in the grounded neutral conductor of the circuit provided they do not open the circuit.

C. *Auto-Transformer Type Dimmers.* An auto-transformer type of dimmer shall be energized by a circuit operating at not more than 150 volts between conductors and the grounded conductor shall be common to both the input and the output of the auto-transformer.

STAGE EQUIPMENT—FIXED

Order 13–5241. Circuit Loads.

Footlights, border lights, and proscenium side lights shall be so arranged that no branch circuit supplying such equipment will carry a load exceeding 15 amperes; provided that where heavy duty lampholders only are used such circuits may conform to the provisions of Section 13–210 for circuits supplying heavy duty lampholders.

Order 13–5242. Footlights.

If the metal trough construction specified in Order 13–5281 is not used, footlights shall consist of individual outlets with lampholders, wired with rigid or flexible metal conduit. The circuit conductors shall be soldered to the lampholder terminals. Disappearing footlights shall be so arranged that the current supply shall be automatically disconnected when the footlights are replaced in the recess designed therefor.

Order 13–5243. Cables for Border Lights.

Cables for border lights shall be Types K, S, SO, SU, SUO, or ST flexible cord. See Table 31 of Chapter 10. The cables shall be suitably supported. Such cables shall be employed only where flexible conductors are necessary.

Order 13–5244. Receptacles.

Receptacles intended for the connection of arc lamps shall have not less than 35 amperes capacity and shall be supplied by conductors not smaller than No. 6. Receptacles intended for the connection of incandescent lamps shall have not less than 15 amperes capacity and

shall be supplied by conductors not smaller than No. 12. Plugs for arc and incandescent receptacles shall not be interchangeable.

Order 13–5245. Lamps in Scene Docks.

Lamps installed in scene docks shall be so located and guarded as to be free from mechanical injury and provide an air space of not less than 2 inches between such lamps and any combustible material.

Order 13–5246. Curtain Motors.

Curtain motors having brushes or sliding contacts shall comply with Order 15–5310.

Order 13–5247. Flue Damper Control.

If stage flue dampers are released by an electrical device, the circuit operating the latter shall be normally closed and shall be controlled by at least 2 externally operable switches, one switch being placed at the electrician's station and the other where designated by the inspection authority. The device shall be designed for the full voltage of the circuit to which it is connected, no resistance being inserted. It shall be located in the loft above the scenery and shall be enclosed in a suitable iron box having a tight, self-closing door.

STAGE EQUIPMENT—PORTABLE

Order 13–5251. Arc Lamps.

Arc lamp frames and standards shall be so installed and guarded as to prevent their becoming grounded.

Order 13–5252. Lights on Scenery.

Brackets on scenery shall be wired internally and the fixture stem shall be carried through to the back of the scenery where a bushing shall be placed on the end of the stem, except that externally wired brackets or other fixtures may be used when wired with Type P or other cords designed for hard usage which shall extend through scenery and without joint or splice in canopy of fixture back and terminate in an approved type stage connector located within 18 inches of the fixture. Fixtures shall be securely fastened in place.

Order 13–5253. Festoons.

Joints in festoon wiring shall be staggered where practicable. Lamps enclosed in lanterns or similar devices of combustible material shall be equipped with approved guards.

Order 13–5254. Special Effects.

Electrical devices used for simulating lightning, waterfalls, and the like, shall be so constructed and located that flames, sparks, or hot particles, cannot come in contact with combustible material.

Order 13–5255. Connectors for Flexible Conductors.

Connectors for flexible conductors shall be so constructed that tension on the cord or cable will not be transmitted to the connections.

The female half of the connector shall be attached to the live end of the cord or cable.

Order 13–5256. Conductors for Portables.

Flexible conductors used to supply portable stage equipment shall be Types K, S, SO, SU, SUO or ST, except that reinforced cord may be used to supply stand lamps if the cord is not liable to severe mechanical injury and is protected by an overcurrent protection at not over 15 amperes.

DRESSING ROOMS

Order 13–5261. Pendants.

Lamp pendants shall not be installed in dressing rooms. Each receptacle shall be provided with a pilot light to indicate when a plug is inserted into the receptacle.

Order 13–5262. Lamp Guards.

All incandescent lamps in dressing rooms, if less than 8 feet from the floor, shall be equipped with open end guards riveted to the outlet box cover or otherwise sealed or locked in place.

Order 13–5263. Switches Required.

Wall switches shall be installed for the control of all lights and receptacles in dressing rooms.

GROUNDING

Order 13–5271. Grounding.

All metal raceways shall be grounded. The metal frames and enclosures of equipment including border lights shall be grounded, except the frames and enclosures of portable equipment on grounded circuits operating at not over 150 volts. Grounding, if employed, shall be done in the manner specified in Section 13–250.

CONSTRUCTION

Order 13–5281. Footlights.

If metal trough construction is employed for footlights, the trough containing the circuit conductors shall be made of sheet metal not lighter than No. 20 USS sheet metal gauge (.0359 inch in thickness) treated to prevent oxidation. Lampholder terminals shall be kept at least ½ inch from the metal of the trough. The circuit conductors shall be soldered to the lampholder terminals.

Order 13–5282. Borders and Proscenium Sidelights.

Borders and proscenium sidelights shall be constructed as prescribed in order 13–5281, shall be suitably stayed and supported, and shall be so designed that the flanges of the reflectors or other adequate guards will protect the lamps from mechanical injury and from accidental contact with scenery or other combustible material.

Order 13–5283. Pockets.

Receptacles intended for the connection of portable stage lighting equipment shall be mounted in suitable pockets or enclosures, and shall comply with the requirements of order 13–5244.

Order 13–5284. Arc Lamps.

Arc lamps shall comply with the following:

A. *General.* Portable arc lamps shall be substantially constructed entirely of metal not less than No. 20 USS sheet metal gauge (.0359 inch), except where approved insulating material is necessary. The design shall be such as to provide proper ventilation while retaining sparks, and to prevent carbons or other live parts of lamp from making contact with metal of hood.

B. *Hoods.* Hoods for other than lens lamps shall have the front opening equipped with a self-closing hinged door frame carrying either wire gauze or glass. Hoods for lens lamps may have a stationary front, and a solid door on either back or side.

C. *Insulation.* Mica shall be used for the insulation of the lamp frame.

D. *Switch.* The switch on the standard shall be of such design that accidental contact with any live part will be impossible.

E. *Rheostats.* Rheostats shall be enclosed in a substantial, properly ventilated metal case affording a clearance of at least 1 inch between case and resistance element. If the rheostat is mounted on the standard, a clearance of 3 inches above the floor shall be maintained.

Asbestos covered Type AA conductors shall be used between the rheostat and the lamp.

F. *Terminals.* If stranded conductors are used, they shall be connected to lamp, rheostat and switch terminals by means of approved lugs or connectors; provided that approved pressure connectors shall be used at arc lamp terminals.

Order 13–5285. Portable Strips.

Portable strips shall be constructed in accordance with the requirements for border lights and proscenium side lights in order 13–5282. The supply cable shall be protected by bushings where it passes through metal and shall be so arranged that tension on the cable will not be transmitted to the connections.

Order 13–5286. Portable Plugging Boxes.

Portable plugging boxes shall conform to the following:

A. *Enclosure.* The construction shall be such that no current-carrying part will be exposed.

B. *Receptacles and Overcurrent Protection.* Each receptacle shall have a current-carrying capacity of not less than 30 amperes, and shall be protected by over-current devices installed in an approved enclosure equipped with selfclosing doors.

C. *Busbars and Terminals.* Busbars shall have a current-carrying capacity equal to the sum of the ampere ratings of all the receptacles. Lugs shall be provided for the connection of the master cable.

PORTABLE SWITCHBOARDS ON STAGE

Order 13–5291. Supply.

Portable switchboards shall be supplied only from outlets especially provided for this purpose. Such outlets shall consist of externally operable, enclosed fused switches or circuit-breakers mounted on the stage wall or at the switchboard in locations readily accessible from the stage floor.

Order 13–5292. Overcurrent Protection.

Circuits from portable switchboards directly supplying equipment containing incandescent lamps of the medium base or smaller types shall be protected by overcurrent devices having a rating or setting of not more than 15 amperes. Circuits for heavy-duty lampholders may be used if overcurrent protection conforms to the provisions of Section 13–210. Other circuits shall be provided with overcurrent devices with a rating or setting not higher than the current required for the connected load.

Order 13–5293. Construction.

Portable switchboards for use on stages shall comply with the following:

A. *Enclosure.* Portable switchboards shall be placed within an enclosure of substantial construction which may be so arranged that the enclosure is open during operation. Enclosures of wood shall be completely lined with sheet metal of not less than No. 24 USS gauge (.0239 inch), and if not of corrosion-resistant type shall be well galvanized, enameled, or otherwise properly coated to prevent corrosion.

B. *Live Parts.* Except as provided for dimmer face plates in paragraph E there shall be no exposed live parts within the enclosure.

C. *Switches and Circuit-Breakers.* All switches and circuit-breakers shall be of the externally-operable, enclosed type.

D. *Circuit Protection.* Overcurrent devices shall be provided in each ungrounded conductor of every circuit supplied through the switchboard. Enclosures shall be provided for all overcurrent devices in addition to the switchboard enclosure.

E. *Dimmers.* The terminals of dimmers shall be provided with enclosures, and dimmer face plates shall be so arranged that accidental contact cannot be readily made with the face-plate contacts.

F. *Interior Conductors.* All conductors within the switchboard enclosure shall be stranded and, except for cables feeding to or from the switchboard, shall be asbestos-covered Type AA or other types approved for a maximum operating temperature of 200C (392F). Each conductor shall have a current-carrying capacity at least equal to the rating of the circuit-breaker, switch or cutout which it supplies, except for conductors for incandescent lamp circuits having overcurrent protection not exceeding 15 amperes. Conductors shall be enclosed in metal troughs or securely fastened in position and shall be bushed where they pass through metal.

G. *Pilot Light.* A pilot light shall be provided within the enclosure and shall be so connected to the circuit supplying the board that the opening of the master switch will not cut off the supply to the lamp. This lamp shall be on an independent circuit having overcurrent protection of a rating or setting of not more than 15 amperes.

H. *Supply Connections.* The supply to a portable switchboard shall be by means of flexible cord (Types K, S, SU or SUO) terminating within the switchboard enclosure or in an externally-operable fused master switch or circuit-breaker. The supply cable shall have sufficient current-carrying capacity to carry the total load on the switchboard and shall be protected by overcurrent devices.

I. *Cable Arrangement.* Cables shall be protected by bushings where they pass through enclosures and shall be so arranged that tension on the cable will not be transmitted to the connections.

J. *Terminals.* Terminals to which stage cables are connected shall be so located as to permit convenient access to the terminals. At terminals not provided with approved pressure connectors the following construction shall be employed:

1. For conductors of No. 10 or larger, solder lugs shall be used.
2. For conductors smaller than No. 10, the strands shall be soldered together when connected to clamps or binding screws not specifically approved as pressure connectors.

SECTION 13-530. MOTION PICTURE STUDIOS AND SIMILAR LOCATIONS

Order 13-5301. Scope.

The requirements of this section shall apply to a motion picture studio, exchange, factory or laboratory building, or a portion of the building in which motion picture films are manufactured, exposed, developed, printed, rewound, repaired or stored. This section shall not apply where only approved slow-burning (cellulose acetate or equivalent) film is used.

Note. The Wisconsin State Building Code covers the requirements as to construction for buildings of this class.

Order 13-5302. Sound Recording.

Installations for sound recording shall conform to the provisions of Section 13-640.

Order 13-5303. Wiring Methods.

The wiring method shall be metal raceways except as provided in Sections 13-640 and 13-800. Portable cables or flexible cord may be used on studio stages and at other locations where fixed wiring methods are impracticable.

Order 13-5304. Side Wall Lamps.

Lampholders on fixtures if less than 8 feet from the floor shall be equipped with vaportight globes or shall be provided with open end guards riveted to the outlet box cover or otherwise sealed or locked in place.

Order 13-5305. Pendent Lamps.

Pendent lamps shall not be installed in permanent dressing rooms.

Order 13-5306. Lamps at Patching Tables.

At patching tables, composition or metal sheathed porcelain keyless lampholders shall be employed and shall be equipped with guards to protect the lamps from mechanical injury.

Order 13-5307. Lamps in Film Vaults.

In film-storage vaults lamps shall be installed on rigid fixtures and enclosed in vaportight globes. Lamps shall be controlled by a double-pole switch located outside the vault. This double-pole switch shall disconnect from the source of supply all conductors terminating in any outlet box in the vault, and no conductors other than those controlled by the double-pole switch shall terminate or pass through any outlet box in the vault. Electric motors or portable lamps shall not be placed in the vault.

Order 13-5308. Portable Lamps.

For portable lamps, composition or metal-sheathed porcelain unswitched lampholders shall be used. The cord shall carry the male end of a pin-plug connector or equivalent, the female end being of such design or so hung that the connector will readily break apart at any position of the cord. The connector shall be kept at least 1 foot from the floor. The lampholder shall be provided with a guard, hook, and handle. The provisions of this order shall not apply to portable lamps used as properties in a motion picture set on a studio stage or similar location.

Order 13-5309. Flexible Cords.

Types S, SO, SU, SUO or ST cord shall be used on portable lamps and equipment, except that portable lamps used as stage properties in a motion picture set on a studio stage or similar location may be used with any approved type of cord with which they may be equipped. See Table 31 of Chapter 10.

Order 13-5310. Motors and Generators.

If motors or generators having brushes or sliding contacts are used they shall meet one of the following conditions:

A. Be of the totally-enclosed, enclosed-fan-cooled, or enclosed-pipe-ventilated types.

B. Be enclosed in separate rooms or housings built of non-combustible materials so constructed as to exclude flyings or lint, and properly ventilated from a source of clean air.

C. Have brush or sliding-contact end of motor enclosed by solid metal covers.

D. Have brushes or sliding-contacts enclosed in substantial, tight, metal housing.

E. Have upper half of brush or sliding-contact end of the motor enclosed by a wire screen or perforated metal and the lower half enclosed by solid metal covers.

F. Have wire screens or perforated metal placed at the commutator or brush ends. No dimension of any opening in the wire screen or perforated metal shall exceed .05 inch, regardless of the shape of the opening and of the material used.

Order 13-5311. Motor and Generator on Studio Stages.

The provisions of order 13-5310 shall not apply to motors or generators used on studio stages, but the live parts of such motors or generators shall be otherwise guarded or enclosed in conformity with the provisions of order 13-5313.

Order 13-5312. Switches.

Switches shall be of the externally-operable type.

Order 13-5313. Live Parts.

Live parts shall be enclosed to prevent accidental contact by persons or objects. Rheostats shall be enclosed and externally operable.

Order 13-5314. Grounding.

All metal raceways, cable armor, and the exposed metal frames of all equipment and enclosures shall be grounded, except pendent and portable lamps operating at not more than 150 volts to ground.

SECTION 13-540. MOTION PICTURE PROJECTORS

Order 13-5401. Professional-Type Projectors.

The professional type of projector, such as is commonly used in theaters and motion picture houses, shall be located in an approved enclosure. Such enclosure shall not be considered as a Hazardous Location as defined in Section 13-500.

The professional projector employs a 35 millimeter film which is 1⅜ inch wide and has on each edge 5.4 perforations per inch. (This includes any projector using nitro-cellulose film.)

Note. The Wisconsin State Building Code contains requirements for enclosures or booths to use with professional type projectors.

Order 13-5402. Non-Professional Type Projectors.

Projectors of the non-professional or miniature type, if employing only approved slow-burning (cellulose acetate or equivalent) film, may be operated without a booth.

Order 13-5403. Sound Recording and Reproduction.

Sound recording and reproduction equipment shall comply with Section 13-640.

EQUIPMENT AND PROJECTORS OF THE PROFESSIONAL TYPE

Order 13-5411. Motor-Driven Projectors.

Motor-driven projectors shall be approved for the purpose as an assembly or shall comply with all of the following conditions:

A. An approved projector shall be used.

B. An approved projector lamp shall be used.

C. Motors shall be so designed or guarded as to prevent ignition of film by sparks or arcs.

D. Projectors shall be in charge of a qualified operator.

Order 13-5412. Conductor Size.

Conductors supplying outlets for projectors of the professional type shall not be smaller than No. 8 and shall be of sufficient size for the projector employed.

Order 13-5413. Conductor Insulation.

Asbestos-covered conductors Type AA or other types of insulated conductors having a maximum operating temperature of 200 C (392F) shall be used on all lamps or other equipment when the ambient temperature at the conductors as installed will exceed 50C (122F).

Order 13-5414. Flexible Cords.

Cords approved for hard service in Table 31 of Chapter 10 shall be used on portable equipment.

Order 13-5415. Lamp Guards.

Incandescent lamps in projection rooms or booths shall be provided with an approved lamp guard unless otherwise protected by non-combustible shades or other enclosures.

Order 13-5416. Location of Equipment.

Motor generator sets, transformers, rectifiers, rheostats, and similar equipment, for the supply or control of current to arc lamps on projectors shall, if practicable, be located in separate rooms. If placed in the projector room, they shall be so located or guarded that arcs or sparks cannot come in contact with film, and motor generator sets shall have the commutator end or ends protected as provided in order 13-5310.

Order 13-5417. Rewinding, Examination and Storage of Extra Films.

It is recommended that the authority having jurisdiction refer to the standards of the National Board of Fire Underwriters. See Publication No. 40, Nitrocellulose Motion Picture Film.

Note. Any requirements in the Wisconsin State Building Code shall be observed.

Order 13-5418. Equipment Prohibited.

No switches, overcurrent devices, or other equipment not normally required or used for projectors, sound reproduction, flood, or other special effect lamps or other equipment shall be installed in such booths or rooms except remote-control switches for the control of auditorium lights or a switch for the motor operating the curtain at the motion-picture screen.

Order 13-5419. Construction and Ventilation.

It is recommended that the authority having jurisdiction over the construction and ventilation of rooms for professional type projectors refer to the standards of the National Board of Fire Underwriters on "Nitrocellulose Motion Picture Film".

CONSTRUCTION

Order 13–5431. Equipment and Projectors of the Professional Type.

Equipment and projectors of the professional type shall comply with the following:

A. *Approved Type.* Projectors and enclosures for arc or incandescent lamps, rectifiers, transformers, rheostats, and similar equipment, shall be of an approved type.

B. *Name Plate.* Projectors and other equipment as set forth in paragraph A of this order, shall be marked with the name or trademark of the maker and with the voltage and current for which they are designed.

Order 13–5432. Projectors of the Non-Professional Type.

Projectors of the non-professional type shall comply with the following:

A. *Approved Type.* Projectors, lamp enclosures, and current controlling devices and similar devices shall be approved as component parts of the projector equipment.

B. *Name-Plate.* Projectors shall be marked with name or trademark of the maker, with the current and voltage for which they are designed, and for projectors of this type using the standard 35 millimeter film, with the wording "For use with slow-burning films only."

C. *Source of Illumination.* The source of illumination shall be a lamp of a type approved for stereopticon use or for motion picture projection.

D. *Film to Be Marked.* The slow-burning (cellulose acetate or equivalent) film shall have a permanent distinctive marker for its entire length identifying the manufacturer and the slow-burning character of the film stock.

Order 13–5433. Booths for Projectors of the Professional Type.

Note. Requirements for booths to be used with projectors of the professional type will be found in the Wisconsin State Building Code.

SECTION 13–560 FARM WIRING

Order 13–5601. General

Farms contain a variety of different locations from dry to corrosive and are generally located in areas where it is difficult to obtain low resistance grounds. In addition farm animals are often in a position where they form a path to ground for any electric charge which may appear on stanchions.

Order 13–5602. Service.

The electric service may be brought to one point or one building and complete service equipment placed at that point or the service entrance equipment may be omitted. If the service entrance equipment is placed at one point, disconnect means shall be placed at each building but service cable and entrance is not necessary. If service disconnect means are not located at one point each building shall have a complete service entrance.

The water pump may be connected in such a way that the opening of other than its own circuit protection will not interrupt service to the pump.

Service equipment and any other outdoor electrical equipment should be placed at least 6 feet above the ground.

Order 13–5603. Grounding.

The neutral conductor and service raceway shall be grounded at the entrance to each building served. If the water system on the farm has less than 50 feet of buried pipe in addition to the well the water system shall be grounded to two made electrodes at least 6 feet apart.

Note: Any metal stanchions or other metal objects in contact with animals should be insulated from the metal in contact with the ground electrode if this is possible. It may be necessary to install a gravity feed to water cups or use hoses arranged to drain when shut off. The metal in contact with animals may be grounded separately. Additional protection for animals in stanchions could be provided by bonding all parts of the stanchions together and placing metal reinforcing rods bonded to the stanchions in the floor.

The neutral conductor shall be grounded at each building even though there may be no service entrance equipment. In addition a ground shall be carried back from metal enclosures of electrical equipment to the point where the neutral is grounded. The ground for non-current carrying parts and the neutral shall be tied together at the grounding point.

Order 13–5604. Wiring.

The following types of wiring may be used for different farm locations:

A. Spaces where livestock is housed, milk house, utility rooms, pump houses, cooling rooms, root cellars, silos, chicken coops, and basements, knob and tube wiring or nonabsorbent (Neoprene jacket) non-metallic sheathed cable shall be used. In addition, insulated boxes, lampholders, ducts, and bushings should be used. The type of insulation recommended is porcelain. If some metal enclosures must be used they shall be mounted on insulating material out of contact with masonry. Entrance switches and distribution cabinets may be placed outside and this is recommended where corrosive, temperature and moisture conditions within the building warrant.

B. Dry portions of living quarters, any type of wiring system authorized by this Code may be used.

C. Workshops, storage sheds, shelters, tobacco sheds, any type of wiring system authorized by this code may be used.

D. Hay mows and granaries. Any type of wiring authorized by this code may be used, provided all lamps are installed in a vertical position and protected with a dust-tight fixture, all wiring is arranged or enclosed to keep hay and grain away, and ducts if used arranged to reduce condensation and to drain.

E. Outside wiring. For outside wiring requirements see Section 13–730.

Chapter 6. Special Equipment

SECTION 13-600. SIGNS AND OUTLINE LIGHTING

Order 13-6001. Scope.

The provisions of this section shall apply to the installation of conductors and equipment for signs and outline lighting as defined in order 1020.

Order 13-6002. Switch Required.

Each outline lighting installation, and each sign of other than the portable type, shall be controlled by an externally-operable switch which will open all ungrounded conductors and shall be suitable for conditions of installation, such as exposure to the weather.

Note. The intent of this rule is to prohibit one sign enclosure being used as a pull box or raceway for conductors supplying other signs or equipment.

Order 13-6003. In Sight of Sign.

The switch required by order 13-6002 shall be within sight of the sign or outline lighting which it controls or may be located elsewhere if capable of being locked in the open position.

Order 13-6004. Rating.

Switches, flashers, and similar devices controlling transformers shall be either of a type approved for the purpose, or have a current rating not less than twice the current rating of the transformers.

Order 13-6005. Grounding.

Signs, troughs, tube terminal boxes and other metal frames shall be grounded in the manner specified in Section 13-250 of this code, unless they are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons. This does not apply to signs of the portable incandescent-lamp type nor to the portable fluorescent-lamp type where the open-circuit voltage does not exceed 150 volts to ground. Isolated non-current-carrying metal parts of outline lighting may be bonded by No. 14 conductors and grounded in accordance with Section 13-250.

Order 13-6006. Load of Branch Circuit.

Circuits shall be so arranged that the number of outlets, lamps, and transformers connected to them, shall in no case place more than 15 amperes on a branch circuit.

Order 13-6007. Marking.

All signs shall be marked with the maker's name, and for incandescent-lamp signs with the number of lampholders, and for electric discharge signs with input amperes at full load and input voltage.

Transformers shall be marked with the maker's name, and transformers for electric discharge signs shall be marked with the input rating in amperes or volt-amperes, the input voltage and the open-circuit high-tension voltage. The marking of the sign shall be visible for inspection after installation.

Order 13-6008. Enclosures.

Enclosures for signs and outline lighting shall conform to the following:

A. *Conductors and Terminals.* Sign boxes, cabinets, and outline troughs shall have conductors and terminals, except the supply leads, enclosed.

B. *Cutouts, Flashers, Etc.* Cutouts, flashers and similar devices, if a part of the sign, shall be in a separate compartment. If not a part of the sign, they shall be enclosed in approved metal boxes the doors of which shall be arranged so that they can be opened without removing obstructions or finished parts of the enclosure.

C. *Enclosures Exposed to the Weather.* Enclosures for outside use shall be weatherproof and shall have an ample number of drain holes, each not larger than ½ inch or smaller than ¼ inch. Wiring connections shall not be made through the bottoms of enclosures exposed to the weather unless the enclosures are of the raintight type.

D. *Material.* Except for portable signs of the indoor type, signs and outline lighting shall be constructed of metal or other noncombustible material. Wood may be used for external decoration if placed at least 2 inches from the nearest lampholder or current-carrying part.

E. *Strength.* Enclosures shall have ample strength and rigidity.

F. *Thickness of Metal.* Sheet copper shall be at least 20 ounce (0.028 inch). Sheet steel may be of No. 28 USS gauge (.0149 inch) except that for outline lighting and for electric discharge signs sheet steel shall be of No. 24 USS gauge (.0239 inch), unless ribbed, corrugated or embossed over its entire surface, when it may be of No. 26 USS gauge (.0179 inch).

G. *Protection of Metal.* All metallic parts of enclosures shall be galvanized or otherwise protected from corrosion.

Order 13-6009. Portable Gas Tube Signs.

All gas tube signs not coming within the definition of portable shall be wired in accordance with the code rule. Satisfactory portable signs may be installed by connection with portable cord.

Note. As applied to Neon or gas tube signs, portable means less than 75 pounds in weight and 10 square feet over the largest surface, with all high tension wires and tube terminals within the sign enclosure proper, and the tubes or lamps fastened only to and not extending beyond the sign surface or background. All portable gas tube signs shall have the metal enclosure grounded by a three-wire cord connected to a three-point receptacle and the portable cord shall be limited to six feet in length.

Order 13–6011. Tube Terminals.

The terminals shall be so designed that the tubing can be replaced without the necessity of exposing uninsulated live parts. If the spring contact type of receptacle is used, it shall be so designed that, even with the tube removed, the live spring will be recessed a distance equal to three times the diameter of the receptacle opening. It is recommended that the primary circuit be controlled by a relay that will open the circuit when a tube in the secondary circuit is broken or removed. Live parts shall be protected by barriers which require other than ordinary tools such as pliers and screw-drivers for removal unless access to the parts requires the disconnection of the primary circuit. (See Order 13–4202)

SIGNS AND OUTLINE LIGHTING—600 VOLTS OR LESS

Order 13–6021. Installation of Conductors.

Conductors shall be installed as follows:

A. *Method of Wiring.* Conductors shall be installed as open conductors on insulators, or in rigid metal conduit, flexible metal conduit, electrical metallic tubing, armored cable, or metal troughing.

B. *Insulation and Size.* Conductors shall be of a type approved for general use and, except in portable signs and for short leads permanently attached to lampholders or ballasts, shall be not smaller than No. 14.

C. *Exposed to the Weather.* Conductors in rigid conduit, electrical metallic tubing, flexible metal conduit, armored cable, or in metal troughing exposed to the weather, shall be of the lead covered type or other type specially approved for the conditions, except where rigid conduit, electrical metallic tubing, or enclosures are made raintight and arranged to drain.

D. *Number of Conductors in Raceway.* For sign flashers the number of conductors in conduit or tubing may be in accordance with Table 9 of Chapter 10.

E. *Open Conductors.* Open conductors on insulators shall comply with the provisions of Orders 13–3002 to 13–3020 inclusive, Section 13–300, and, if outdoors, Section 13–730, except that the separation between conductors need be only 2 inches; provided, that open conductors may be supported by lampholders located not more than 1 foot apart.

F. *Conductors Soldered to Terminals.* Where the conductors are fastened to lampholders other than of the pin type, they shall be soldered to the terminals and the exposed parts of conductors and terminals shall be treated to prevent corrosion. Where the conductors are fastened to pin type lampholders which protect the terminals from the entrance of water, and which have been found acceptable for sign use, the conductors shall be of the stranded type but need not be soldered to the terminals.

Order 13–6022. Lampholders.

Lampholders shall be of the unswitched type having bodies of suitable insulating material and shall be so constructed and installed as to prevent turning. Miniature lampholders shall not be employed for outdoor signs and outline lighting.

SIGNS AND OUTLINE LIGHTING—EXCEEDING 600 VOLTS

Order 13–6031. Installation of Conductors.

Conductors shall be installed as follows:

A. *Wiring Method.* Conductors shall be installed as open work, as concealed conductors on insulators, or in rigid or flexible metal conduit or electrical metallic tubing. Conductors may be run from the ends of tubing to the grounded midpoint of transformers specifically designed for the purpose and provided with terminals at the midpoint. Where such connections are made to the transformer grounded midpoint, the connections between the high voltage terminals of the transformer and the line ends of the tubing shall be as short as possible.

B. *Insulation and Size.* Conductors shall be of a type approved for the purpose and for the voltage of the circuit, and shall be not smaller than No. 14.

C. *Bends in Conductors.* Sharp bends in the conductors shall be avoided.

D. *Open Conductors—Indoor.* Open conductors indoors shall be mounted on non-combustible, non-absorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least 1½ inches shall be maintained between conductors and between conductors and other objects. Conductors shall not be located where subject to mechanical injury.

E. *Concealed Conductors on Insulators—Indoors.* Concealed conductors on insulators shall be separated from each other and from all objects other than the insulators on which they are mounted by a spacing of not less than 1½ inches for voltages above 10,000 volts, and not less than 1 inch for voltages of 10,000 or less. They shall be installed in channels lined with non-combustible material and used for no other purpose, except that the primary circuit conductors may be in the same channel. The insulators shall be of non-combustible, non-absorptive material.

F. *Show Windows and Similar Locations.* If conductors hang freely in the air, away from combustible material, and if not subject to mechanical injury, as in some show window displays, they need not be otherwise protected.

G. *Conductors in Raceways.* If the conductors are covered with lead or other metal sheathing, the covering shall extend beyond the end of the raceway, and the surface of the cable shall not be injured where the covering terminates. In damp or wet locations, the insulation on all conductors shall extend beyond the metal covering or raceway at least 4 inches for voltages over 10,000, 3 inches for volt-

ages over 5,000 but not exceeding 10,000 and 2 inches for voltages of 5,000 or less. In dry locations the insulation shall extend beyond the end of the metal covering or raceways not less than 2½ inches for voltages over 10,000, 2 inches for voltages over 5,000 but not exceeding 10,000 and 1½ inches for voltages of 5,000 or less. For conductors at grounded midpoint terminals, no spacing is required. Not more than 20 feet of cable from a single transformer shall be run in metal raceway where the potential between the cable and the raceway is more than 5,000 volts.

H. *Open Conductors—Outdoors.* Open conductors outdoors shall be mounted on non-combustible, non-absorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least 2 inches shall be maintained between conductors and between conductors and other objects. Where subject to mechanical injury or where within reach from ground, roof, or window, conductors shall be enclosed in raceways or suitably guarded. If guarded, a spacing of not less than 1½ inches shall be maintained between conductors and the enclosure unless the enclosure is non-conducting and non-combustible.

Order 13–6032. Transformers.

Transformers shall comply with the following:

A. *Voltage.* The transformer secondary open-circuit voltage shall not exceed 15,000 volts with an allowance on test of 1000 volts additional. In end-grounded transformers the secondary, open-circuit voltage shall not exceed 7,500 volts with an allowance on test of 500 volts additional.

B. *Type.* Transformers shall be a type approved for the purpose and shall be limited in rating to a maximum of 4500 volt-amperes. Open core-and-coil type transformers shall be limited to 5,000 volts with an allowance on test of 500 volts, and to indoor applications in small portable signs. Transformers for outline lighting installations shall have secondary current ratings not in excess of 30 milliamperes unless they and all wiring connected to them are installed in accordance with the provisions of Section 13–410 for electric discharge lighting of the same voltage.

C. *Exposed to Weather.* Transformers used outdoors shall be of the weatherproof type or shall be enclosed in the sign body or in a separate metal box.

D. *Transformer Secondary Connections.* The high-voltage windings of transformers shall not be connected in parallel; and shall not be connected in series, except that two transformers each having one end of its high-voltage winding connected to the metal enclosure may have their high-voltage windings connected in series to form the equivalent of a midpoint grounded transformer. The grounded ends shall be connected by insulated conductors not smaller than No. 14.

E. *Accessibility.* Transformers shall be accessible.

Order 13–6033. Tubing.

Electric discharge tubing shall conform to the following:

A. *Design.* The tubing shall be of such length and design as not to cause a continuous over-voltage on the transformer.

B. *Support.* Tubing shall be adequately supported on non-combustible, non-absorptive supports. Tubing supports should, if practicable, be adjustable.

C. *Contact with Flammable Material and Other Surfaces.* The tubing shall be free from contact with flammable material and shall be located where not normally exposed to mechanical injury. If operating in excess of 7,500 volts, the tubing shall be supported on non-combustible, non-absorptive, insulating supports which maintain a spacing of not less than ¼ inch between the tubing and the nearest surface.

Order 13–6034. Terminals and Receptacles for Electric Discharge Tubing.

Terminals and receptacles for electric discharge tubing shall comply with the following:

A. *Terminals.* The terminals of the tubing shall be inaccessible to unqualified persons and isolated from combustible material and grounded metal or shall be enclosed. If enclosed they shall be separated from grounded metal and combustible material by non-combustible, non-absorptive, insulating material approved for the purpose or by 1½ inches of air. Terminals shall be relieved from stress by the independent support of the tubing.

B. *Tube Connections Other Than With Receptacles.* If tubes do not terminate in receptacles designed for the purpose, all live parts of tube terminals and conductors shall be so supported as to maintain a separation of at least 1½ inches between conductors or between conductors and any grounded metal.

C. *Receptacles.* Electrode receptacles for the tubing shall be of non-combustible, non-absorptive insulating material approved for the purpose.

D. *Bushings.* Where electrodes enter the enclosure of outdoor signs or of an indoor sign operating at a voltage in excess of 7500 volts, bushings shall be used unless receptacles are provided or the sign is wired with bare wire mounted on approved supports which maintain the tubing in proper position. Bushings shall be of non-combustible, non-absorptive material. Where bare wiring is used, the conductor shall be not less than No. 14 solid copper, shall be supported so as to prevent sagging and lessening of the spacing required elsewhere in this section, and electrode terminal assemblies shall be of an approved type and supported not more than 6 inches from the electrode terminals.

E. *Show Windows.* In the exposed type of show window signs, terminals shall be (1) enclosed by receptacles approved for the purpose or (2) where hanging in air, free from grounded surfaces,

enclosed in sleeves of vulcanized fiber, phenolic composition, or other suitable material which overlaps all live parts by at least ½ inch.

F. *Receptacles and Bushing Seals.* A flexible, non-conducting seal may be used to close the opening between the tubing and the receptacle or bushing against the entrance of dust or moisture. This seal shall not be in contact with grounded conductive material and shall not be depended upon for the insulation of the tubing.

G. *Enclosures of Metal.* Metal enclosures for electrodes shall be of not less than No. 24 USS gauge (.0239 inch) sheet metal.

H. *Enclosures of Insulating Material.* Enclosures of insulating material shall be non-combustible, non-absorptive and approved for the voltage of the circuit.

Order 13-6035. Switches on Doors.

Doors or covers giving access to uninsulated parts of indoor signs or outline lighting exceeding 600 volts and accessible to the general public, shall either be provided with interlock switches which on the opening of the doors or covers disconnect the primary circuit, or shall be so fastened that the use of other than ordinary tools will be necessary to open them.

Order 13-6036. Marking.

All signs shall be marked with the maker's name, and for incandescent-lamp signs with the number of lampholders, and for electric discharge signs with input amperes at full load and input voltage. Transformers shall be marked with the maker's name, and transformers for electric discharge signs shall be marked with the input rating in amperes or volt-amperes, the input voltage and the open-circuit high-tension voltage. The marking of the sign shall be visible for inspection after installation.

Order 13-6037. Enclosures.

Enclosures for signs and outline lighting shall conform to the following:

A. *Conductors and Terminals.* Sign boxes, cabinets, and outline troughs shall have conductors and terminals, except the supply leads, enclosed.

B. *Cutouts, Flashers, Etc.* Cutouts, flashers, and similar devices shall be enclosed in metal boxes, the doors of which shall be arranged so that they can be opened without removing obstructions or finished parts of the enclosure.

C. *Enclosures Exposed to Weather.* Enclosures for outside use shall be weatherproof and shall have an ample number of drain holes, each not larger than ½ inch or smaller than ¼ inch.

D. *Material.* Except for portable signs of the indoor type, signs and outline lighting shall be constructed of metal or other non-combustible material. Wood may be used for external decoration if placed at least 2 inches from the nearest lampholder or current carrying part.

E. *Strength.* Enclosures shall have ample strength and rigidity.

F. *Thickness of Metal.* Sheet copper shall be at least 20 ounce (0.028 inch). Sheet steel may be of No. 28 USS gauge (.0149 inch) except that for outline lighting and for electric discharge signs sheet steel shall be of No. 24 USS gauge (.0239 inch), unless ribbed, corrugated or embossed over its entire surface, when it may be of No. 26 USS gauge (.0179 inch).

G. *Protection of Metal.* All metallic parts of enclosures shall be galvanized or otherwise protected from corrosion.

SECTION 13-610. CRANES AND HOISTS

Order 13-6101. Scope.

The provisions of this section shall apply to the installation of cranes, crane runways, hoists, and monorails. Installations in hazardous locations shall comply with the provisions of Order 13-5083.

WIRING

Order 13-6111. Types of Conductors.

Conductors shall be of the rubber-covered or the thermoplastic type except:

A. *Exposed to High Temperatures.* Conductors exposed to severe external heat, and those between resistors and contact plates, if not exposed to moisture, shall be asbestos insulated (Types AA or AIA), or if the temperature does not exceed 90C (194F), slow-burning (Type SB). If exposed to moisture, such conductors shall be rubber-covered or Type AVL. If rubber-covered conductors are grouped, the group shall be taped with a flameproof covering.

B. *Contact Conductors.* Contact conductors along runways, crane bridges and monorails may be bare and may be of hard drawn copper, or aluminum, or steel in the form of tees, angles, tee rails, or other stiff shapes.

C. *Flexible Conductors.* Flexible conductors may be used to convey current and where practicable, cable reels or take-up devices may be employed.

D. *Varnished Cambric Conductors.* Varnished-cambric conductors (Type V) or asbestos varnished cambric (Types AVA and AVB) may be used in dry locations.

Order 13-6112. Conductor Sizes.

Conductors shall be of the following sizes:

A. *Current-carrying Capacity.* The allowable current-carrying capacities of conductors shall be as shown in the following table:

The allowable current-carrying capacities of conductors having other than rubber or thermoplastic insulation, supplying motors of 5-, 15-, 30-, or 60 minute ratings, shall be as given in Tables 1 and 2, Chapter 10, increased by 10 per cent.

For the carrying capacity of conductors between controllers and resistors see Order 13-4313.

Current-carrying Capacities of Conductors Having Rubber or Thermoplastic Insulation Which Supply Crane and Hoist Motors

Size AWG MCM	AMPERES	
	For Motors Having 30- and 60-Minute Short-Time Ratings	For Motors Having 5- and 15-Minute Short-Time Ratings
16	10	11
14	20	22
12	25	28
10	35	39
8	45	50
6	57	63
5	65	72
4	77	85
3	90	99
2	107	118
1	130	143
0	160	176
00	195	215
000	245	270
0000	300	330
250	350	385
300	410	450
350	460	510
400	515	570
450	565	620
500	620	680

B. *Minimum No. 14.* Conductors shall not be smaller than No. 14 except:

1. On small cranes and hoists, No. 16 may be used provided the conductors are protected against mechanical injury.

2. On operating circuits, No. 16 may be used provided the conductors are protected against mechanical injury.

C. *Contact Conductors.* The size of contact wires shall be not less than the following:

Distance between end strain insulators	Size of wire
0–30 feet	No. 6
31–60 feet	No. 4
over 60 feet	No. 2

Order 13–6113. Wiring Method.

Conductors shall be enclosed in raceways, except:

A. *Bare Conductors.* Bare conductors may be used as contact conductors.

B. *Open Conductors.* Short lengths of open conductors at resistors and collectors need not be enclosed.

C. *Flexible Connections.* Where flexible connections are necessary to motors and similar equipment, flexible metal conduit, armored cable, multiple conductor rubber-covered cable or an approved nonmetallic enclosure may be employed. Approved take-up reels or other approved methods of protecting the multiple conductor cable against injury shall be provided.

D. *Pendent Push-Button Stations.* Where multiple conductor cable is used with a suspended push-button station, the station must be supported in some satisfactory manner that will protect the electrical conductors against strain.

Order 13–6114. Raceway Terminal Fittings.

Conductors leaving raceways shall comply with the provisions of Orders 13–3008 and 13–3009.

Order 13–6115. Common Return.

If a crane or hoist is operated by more than one motor, a common return conductor of proper current carrying capacity may be used.

CONTACT CONDUCTORS

Order 13–6121. Installation of Contact Conductors.

Bare contact conductors shall conform to the following:

A. *Contact Wires.* If wires are used as contact conductors they shall be secured at the ends by means of approved strain insulators and shall be so mounted on approved insulators that the extreme limit of displacement of the wire will not bring the latter within less than 1½ inches from the surface wired over.

B. *Supports Along Runways.* Main contact conductors carried along runways shall be supported on insulating supports placed at intervals not exceeding 20 feet, and these supports shall be insulating except for grounded rail conductors as provided in paragraph E of this order. Such conductors shall be separated not less than 6 inches except for monorail hoists where a spacing of not less than 3 inches may be used. Where necessary, intervals between insulating supports may be increased up to 40 feet, the separation between conductors being increased proportionately.

C. *Supports on Bridges.* Bridge contact conductors shall be kept at least 2½ inches apart and, if the span exceeds 80 feet, insulating saddles shall be placed at intervals not exceeding 50 feet.

It is recommended that the distance between wires be greater than 2½ inches where practicable.

D. *Supports for Rigid Conductors.* Conductors along runways and crane bridges, if of the rigid type specified in Order 13–6111B, shall be carried on insulating supports spaced at intervals of not more than 80 times the vertical dimension of the conductor, but in no case greater than 15 feet, and spaced apart sufficiently to give a clear electrical separation of conductors or adjacent collectors of not less than 1 inch.

E. *Track as Circuit Conductor.* Monorail, tramrail or crane-runway tracks may be used as a conductor of current for one phase of a three-phase alternating-current system furnishing power to the carrier, crane or trolley, provided the following conditions are fulfilled:

1. The conductors for supplying the other two phases of the power supply shall be insulated.

2. The power for all phases shall be obtained from an insulating transformer.

3. The voltage shall not exceed 300 volts.

4. The rail serving as a conductor shall be effectively grounded at one point only, preferably at the transformer.

F. *Electrical Continuity of Contact Conductors.* All sections of bare rigid contact conductors shall be mechanically joined to provide a continuous electrical connection.

G. *Not to Supply Other Equipment.* Contact conductors shall not be used as feeders for any equipment other than the crane or cranes which they are primarily designed to serve.

H. *Isolating or Guarding Contact Conductors.* Except in locations to which only qualified persons are admitted, contact conductors shall be so isolated by elevation or be provided with suitable guards so arranged that persons cannot inadvertently touch the current-carrying parts while in contact with the ground or with conducting material connected to the ground.

Order 13-6122. Collectors.

Collectors shall be so designed as to reduce to a minimum sparking between them and the contact conductor, and when operated in rooms used for the storage of easily ignitible combustible fibers and materials the requirements of Order 13-5083 shall be complied with.

CONTROL

Order 13-6131. Runway Conductor Disconnecting Means.

A disconnecting means shall be provided between the runway contact conductors and the power supply. Such disconnecting means shall consist of a motor-circuit switch or circuit-breaker, except that a general-use switch may be used when the disconnecting means is provided in accordance with Order 13-6132. This disconnecting means shall be readily accessible and operable from the ground, shall be arranged to be locked in the open position, shall open all ungrounded conductors simultaneously, and shall be placed within sight of the crane or hoist and the runway contact conductors.

Order 13-6132. Disconnecting Means for Crane.

If cranes are operated from cages or cabs, a motor-circuit switch or circuit-breaker shall be provided in the leads from the runway contact conductors. The switch or circuit-breaker shall be in the cage or cab or mounted on the bridge and operable from the cage or cab when the trolley is at one end of the bridge.

Order 13-6133. Rating of Disconnecting Means for Crane.

On both alternating-current and direct-current crane protective panels, the continuous ampere rating of the switch or circuit-breaker required by Order 13-6132, and main-line contactors, shall be not less than 50 per cent of the combined short-time ampere ratings of the motors, nor less than 75 per cent of the sum of the short-time ampere ratings of the motors required for any single crane motion.

Order 13-6134. Limit Switch.

A limit switch shall be provided for upper limit of travel of crane hoists.

OVERCURRENT PROTECTION

Order 13-6141. Contact Conductors.

The main contact conductors shall be protected by an overcurrent device.

Order 13-6142. Crane Motors.

If more than one motor is employed on a crane, each motor shall have individual overcurrent protection as provided in Section 13-430, except that if two motors operate a single hoist, carriage, truck, or bridge, and are controlled as a unit by one controller, the pair of motors with their leads may be protected by a single overcurrent device which shall be located in the cage or cab if there is one.

Order 13-6143. Resistors—Enclosure.

If a crane operates over readily combustible material, the resistors shall be placed in a well-ventilated cabinet composed of non-combustible material so constructed that it will not emit flames or molten metal, except where the resistors are located in a cage or cab constructed of non-combustible material which encloses the sides of the cage or cab from the floor to a point at least 6 inches above the top of the resistors.

Order 13-6144. Grounding.

Motor frames, tracks, the entire frame of a crane or hoist, and cases of controllers shall be grounded in the manner specified in Section 13-250. Small portable hoists shall be grounded when required by Order 13-2545.

SECTION 13-615. TROLLEY CONDUCTORS

Order 13-6151. Scope.

The provisions of this section shall apply to installations of trolley wires and feeders for supplying electric locomotives and cars.

Order 13-6152. Insulation of Trolley Wires.

Trolley wires shall have at least two separate and distinct insulations from the ground. A wooden pole or structure shall be considered as one insulation.

Order 13-6153. Control of Trolley Wires and Feeders.

Trolley wires and feeders shall be provided with a means by which they can be disconnected from their source of current.

SECTION 13-620. ELEVATORS

(See Wisconsin State Elevator Code for construction requirements.)

Order 13-6201. Scope.

This section shall apply to the electrical equipment and wiring used in connection with elevators and dumbwaiters. Installations in hazardous locations shall also comply with Section 13-500. Installations in garages shall also comply with Section 13-510.

Order 13-6202. Voltage Limitations.

The following voltage limitations shall apply to elevator control and operating equipment:

A. *Car Control System.* No part of any electric circuit having a voltage in excess of 750 shall be used on any car control system. Circuits of higher voltage may be used in machine rooms or penthouses for the operation of motors and brakes, provided that all control and signal wiring is thoroughly insulated from such power circuits, and all machine frames and metal, hand operated ropes are permanently grounded.

B. *Elevator Control Device.* The maximum voltage permitted on elevators hereafter installed shall not exceed 300 volts to ground on any elevator operating devices in the car, or at the landing, including push buttons of the elevator signalling circuit.

C. *Push Buttons.* The maximum voltage permitted on the push buttons of elevator signalling circuits shall be 300 volts to ground.

Order 13-6203. Live Parts Enclosed.

All live parts of electrical apparatus in or on elevator cars or in elevator hoistways shall be enclosed to protect against accidental contact.

Order 13-6204. Insulation of Conductors.

The insulation of conductors installed in or on elevator equipment shall comply with the following:

A. *In Auxiliary Gutters.* In auxiliary gutters used in machine rooms, under controllers, starters and similar apparatus for elevator machines, conductors shall be of the rubber-covered or thermoplastic-covered type.

B. *Control-Panel Wiring.* Conductors between main circuit resistors and the back of control panels shall be suitable for an operating temperature of not less than 90C (194F). All other wiring on control panels, unless subjected to a temperature exceeding 60C (140F), shall be of the rubber-covered or thermoplastic-covered type or shall be of other type specially approved for the purpose.

C. *Elevator Controller Circuits.* Conductors or groups of conductors having flame retardant outer covering shall not be used as connections for the operating circuits of elevator controllers unless such outer covering is also moisture resistant.

Asbestos and other moisture absorbing coverings are not recommended for the operating circuit, as the covering when damp may carry enough current to cause the controller to function incorrectly and this incorrect functioning may be a life hazard.

D. *Traveling Cables.* Traveling cables used as flexible connections between the car and the hoistway shall be Types E or EO elevator cable, or other approved type, and shall have a flame-retardant and moisture-resistant outer covering.

E. *Fixed Wiring.* For wiring for elevator operating, control circuits, and signalling circuits, conductors shall be rubber-covered or thermoplastic-covered with insulation of not less than 2/64 inch in thickness.

Order 13-6205. Minimum Size of Conductors.

The minimum size of conductors for elevator wiring shall be as follows:

A. For lighting circuits, No. 14, except that for flexibility two or more No. 16 conductors may be used in parallel in traveling cables and on the car.

B. For elevator operating and control circuits, No. 16.

C. For signal circuits and for fixtures, No. 18.

Order 13-6206. Wiring Method.

The following wiring methods shall be employed:

A. *In Hoistways.* Conductors located in the hoistway, except traveling cables and conductors used in signal systems of Classes 1 or 2, shall be installed in rigid conduit or electrical metallic tubing, except that flexible conduit or armored cable may be used between riser and limit switches, interlocks, push buttons or similar devices.

B. *On the Car.* Conductors and traveling cables on the car shall be run in rigid conduit, electrical metallic tubing or wireways; except that short runs of:

1. Flexible conduit or armored cable may be used if so located as to be kept free from oil, and securely fastened in place.

2. Type S, SO, SU, or SUO cord may be used as the flexible connection between the fixed wiring on the car and the switch on the car door or gate if securely fastened in a position not liable to mechanical injury.

C. *Between Motors, Generators and Control Panels.* The conductors of circuits between motors, generators, and control panels may be grouped without any additional insulation of the separate conductors if the complete group is either taped or corded, and such covering properly painted with an insulating paint; provided that such conductors are not over 6 feet long, are supported at intervals not more than 3 feet and are not so located as to be subject to mechanical damage. If motor-generators are used with elevator motors and both are located adjacent to or underneath the control equipment and are provided with extra length terminal leads, such leads may be extended to connect directly to the elevator controller or motor-generator starter terminal studs without regard to the carrying capacity re-

quirements of Sections 13-430 and 13-445; provided, that no such lead is longer than 6 feet.

Where continuity of elevator service is of vital importance, it is recommended that feeders serving such elevators be so installed that the elevator service is not likely to be interrupted in case of a fire in the building.

INSTALLATION OF CONDUCTORS

Order 13-6211. Raceway Terminal Fittings.

Conductors leaving raceways shall comply with the provisions of Orders 13-3008 and 13-3009, but in no case shall the raceway terminate less than 6 inches from the floor.

Order 13-6212. Split Fittings.

Split fittings or clamp fittings may be used on exposed conduit or electrical metallic tubing except where the conduit or tubing contains feeders.

Order 13-6213. Supports.

Supports for pipes, conduits, and armored cable shall be securely fastened to the guide rail or hoistway construction.

Order 13-6214. Number of Conductors in Raceway.

The number of operating and control circuit conductors installed in a raceway may be in accordance with Table 9 of Chapter 10.

Order 13-6215. Auxiliary Gutters.

The restrictions of Order 13-3742 as to length of auxiliary gutters, and of Order 13-3745 as to number of conductors in auxiliary gutters, shall not apply.

Order 13-6216. Lighting and Signal Circuits Separate.

Conductors of car lighting circuits, and signal systems when not an integral part of the elevator wiring system, shall be separated and run in separate traveling cables and raceways.

Order 13-6217. Different Systems in One Cable or Raceway.

Conductors for elevator circuits, including operating, control and power conductors, and signal conductors when an integral part of the wiring system, may be run in the same traveling cable or raceway system when the power supply is from the same source, even though the characteristics of the voltage and/or current may be changed within the system by rectifying, transforming or other converting devices supplied from the elevator feeder circuit; provided that all conductors are insulated for the maximum voltage found in the cable or raceway system, and the live parts of the equipment are insulated from ground for this maximum voltage. Such a traveling cable or raceway may also include a pair of telephone conductors to serve a telephone in the car, provided such conductors are insulated for the maximum voltage found in the cable or raceway system.

Order 13-6218. Foreign Wires.

No electric conduit or cables, except those used to furnish or control power, light, heat or signals for the elevator or hoistways, shall have an opening, terminal, outlet or junction within the hoistway, but shall be continuous between outlets or terminals situated entirely outside the hoistway.

It is not intended to prohibit the interruption of long runs for the purpose of supporting or pulling in conductors, and pull boxes may be installed for this purpose.

TRAVELING CABLES

Order 13-6231. Cable Assembly.

Traveling cables for circuits other than signal shall be of a composite assembly of steel and copper strands or may have one or more supporting fillers of cotton or hemp rope, or of cotton-covered or rubber-covered steel wire laid up with the conductors under the outer covering of the cable. In cables containing six or more conductors the steel supporting strands shall run straight through and not be cabled with the conductors.

Order 13-6232. Suspension.

Traveling cables for all signal circuits, and for all other circuits not over 100 feet in length, may be suspended by suitable clamps if the cables are so constructed that the weight of the cable is not carried by the individual conductors.

Order 13-6233. Hazardous Locations.

In hazardous locations, traveling cables shall be secured to explosion proof cabinets by heavy-duty rubber-bushed threaded connector bushings sealed off at the enclosure as provided in Order 13-5015. For traveling cables for use in hazardous locations see Table 31.

Order 13-6234. Protection for Swinging Cables.

Wherever the traveling cables in swinging may come in contact with projections or corners of the building construction in the hoistway, such as I-beams, ledges and the like, such irregular surfaces shall be made smooth by covering with heavy gauge sheet metal or other suitable means.

CONTROL

Order 13-6241. Disconnecting Means.

A manually operated circuit-breaker or disconnecting switch of the enclosed type opening all conductors shall be installed separately in the supply circuit of every electrically driven elevator machine, dumbwaiter or motor generator set hereafter installed. This switch shall be provided with proper overcurrent protection. No provision shall be made to close the disconnecting switch from any other part of the

building. This switch shall be located where visible from the elevator machine or motor generator set, unless special permission is given to locate it elsewhere.

Note. It is recommended that this switch be located in the machine room at the lock jamb side of the entrance door.

Order 13–6242. Limit Switches.

Every electric elevator with an electric brake shall be equipped with final limit switches at each terminal of travel which shall automatically interrupt the power circuits and stop the car in case of overtravel, except on electric oil hydraulic elevators.

Every electric elevator with an electric brake shall be equipped with directional limit switches at each terminal of travel. Limit switches as outlined above shall be mounted on the guide rails and directly operated by a cam attached to the car.

Every electric drum type elevator with a mechanical brake shall be equipped with an approved machine automatic terminal stopping device, which shall automatically stop the machine in the event the car over-travels either of the terminal landings.

Note: See Section 13–510 for elevators located in garages. See Wisconsin Elevator Code.

Order 13–6243. Phase Protection.

Electric elevators driven by polyphase alternating current motors shall be equipped with a device (reverse phase relay) which shall prevent starting the motors if:

A. The phase rotation is in the wrong direction, or

B. There is a failure in any phase.

Exception: Electric elevators, equipped with final limit switches as outlined in Order 13–6242 and arranged to cut all wires, or all except one, which shall be the grounded conductor on grounded systems, and so connected that after the car over-travels it cannot be moved until the phase reversal is corrected.

OVERCURRENT PROTECTION

Order 13–6251. No. 18 Conductors.

If No. 18 conductor is used for signal circuits, it shall be protected by fuses rated at not to exceed 3 amperes.

MACHINE ROOM

Order 13–6261. Guarding Equipment.

The elevator machine and controller shall be installed in a room set aside for that purpose, or isolated by elevation or by means of an enclosure or wire grille or the like, to prevent accidental contact by persons or objects. This room may also contain other machinery used for the control and signaling of the elevator.

Order 13–6262. Clearance Around Control Panels.

The following clearances shall be provided:

A. *Grouped Panels.* If a group of three or more elevator control panels having wiring on the rear is located in a single machine room, there shall be a working space of at least 36 inches back of the live parts, and not less than 18 inches on at least one side of the group. There shall also be at least 36 inches of working space in front of the panels.

B. *Single or Double Panels.* An installation consisting of one or two panels shall have at least 24 inches working space in the rear, and at least 36 inches working space in the front of the panel or panels; and there shall be at least 18 inches working space on one side if the panel is single, and on each side if the panel is a double one. Smaller clearances may be authorized in certain specific cases by special permission.

This is not intended to forbid mounting controllers on the machine, enclosing the rear of control panels in removable cabinets, nor the placing of auxiliary equipment in front or rear of control panels, provided the working space is not appreciably restricted. If such cabinets are installed, the prescribed dimensions of clear space apply when the back of the cabinet is removed.

GROUNDING

Order 13–6271. Metal Raceways Attached to Cars.

Conduit or armored cable attached to elevator cars shall be bonded to grounded metal parts of the car with which they come in contact.

Order 13–6272. Electric Elevators.

For electric elevators, the frames of all motors, elevator machines, controllers and the metal enclosures for all electrical devices in or on the car or in the hoistway shall be grounded.

Order 13–6273. Non-Electric Elevators.

For elevators other than electric, if any electrical conductors are attached to the car, the metal frame of the car, if normally accessible to persons, shall be grounded.

Order 13–6274. Hand-Operated Cables.

All hand-operated metallic shifting ropes or cables shall be grounded.

Order 13–6275. Inherent Ground.

Equipment mounted on members of the structural metal frame of a building, shall be deemed to be grounded if building frame is grounded in accordance with Section 13–250. Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded when the machine is grounded in accordance with Section 13–250.

SECTION 13-630. ELECTRIC WELDERS

Order 13-6301. Scope.

This section amplifies or modifies parts of Chapters 1 to 4 inclusive of this code in order to properly cover the operating conditions to which electric welder installations are subjected. Accordingly the appropriate provisions of Chapters 1 to 4 inclusive apply to the component parts of electric welder installations except as otherwise provided in this section. This section covers extensively used types of welders which require special treatment, as distinguished from welders which do not require special treatment and welders not in common use and not yet developed to the extent that rating and construction standards are possible.

TRANSFORMER ARC WELDERS

Order 13-6311. Capacity of Supply Conductors.

The current-carrying capacity of conductors shall be as follows:

A. *Individual Welders.* The rated current-carrying capacity of the supply conductors shall be not less than the rated primary current of the welder.

B. *Group of Welders.* The rated current-carrying capacity of conductors which supply a group of welders may be less than the sum of the rated primary currents of the welders supplied. The conductor rating shall be determined in each case according to the welder loading based on the use to be made of each welder and the allowance permissible in the event that all the welders supplied by the conductors will not be in use at the same time. The load value used for each welder shall take into account both the magnitude and the duration of the load while the welder is in use.

Conductor ratings based on 100 per cent of the rated primary current of the two largest welders, 85 per cent for the third largest welder, 70 per cent for the fourth largest welder, and 60 per cent of the rated primary current for all the remaining welders, should provide an ample margin of safety under high production conditions with respect to the maximum permissible temperature of the conductors. Percentage values lower than those given are permissible in cases where the work is such that a high operating duty cycle for individual welders is impossible.

Order 13-6312. Overcurrent Protection.

Overcurrent protection shall be as provided in paragraphs A and B. If the nearest standard rating of the overcurrent device used is under the value specified in this order or if the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher rating or setting may be used.

A. *For Welders.* Each welder shall have overcurrent protection rated or set at not more than 200 per cent of the rated primary current of the welder, except that an overcurrent device is not required for a welder having supply conductors protected by an overcurrent device rated or set at not more than 200 per cent of the rated primary current of the welder.

B. *For Conductors.* Conductors which supply one or more welders shall be protected by an overcurrent device rated or set at not more than 200 per cent of the conductor rating.

Order 13-6313. Controller.

A controller shall be provided in the supply connection of each welder which is not equipped with a controller mounted as an integral part of the welder. The controller shall be a motor-circuit switch or a circuit-breaker. The ampere rating shall be not less than the rated primary current of the welder. The horsepower rating of a switch used as a controller shall be not less than the numerical value obtained by multiplying the rated primary current of the welder by 0.1, 0.2 or 0.25, respectively, for 220-, 440- and 550-volt welders. These factors apply to 2-pole switches.

Order 13-6314. Name Plate.

A name-plate giving the following information shall be provided: name of manufacturer; frequency; primary voltage; rated primary current; maximum open-circuit secondary voltage; rated secondary current; basis of rating, i.e., the duty cycle, 30-minute rating or 60-minute rating.

MOTOR-GENERATOR ARC WELDERS

Order 13-6321. References.

Motor-generator arc welder installations are covered by the appropriate orders of Chapters 1 to 4 inclusive applicable to conductors, motors, generators and associated equipment. Referring specifically to the motor supply connections, the following orders apply in addition to such other provisions as may be applicable. Conductor rating, Orders 13-4312 and 13-4316. Overcurrent protection: for motors, Order 13-4323; for conductors, Order 13-4342. Controllers, Orders 13-4304, 13-4305 and 13-4383. Disconnecting means, Order 13-4407.

RESISTANCE WELDERS

Order 13-6331. Capacity of Supply Conductors.

The current-carrying capacity of the supply conductors necessary to limit the voltage drop to a value permissible for the satisfactory performance of the welder is usually greater than that required to prevent overheating as prescribed in paragraphs A and B.

A. *Individual Welders.* The rated current-carrying capacity for conductors for individual welders shall conform to the following:

1. *Varying Operation.* The rated current-carrying capacity of the supply conductors for a welder which may be operated at different times at different values of primary current or duty cycle shall be not less than 70 per cent of the rated primary current for seam and auto-

matically fed welders, and 50 per cent of the rated primary current for manually-operated non-automatic welders.

2. *Specific Operation.* The rated current-carrying capacity of the supply conductors for a welder wired for a specific operation for which the actual primary current and duty cycle are known and remain unchanged shall be not less than the product of the actual primary current and the multiplier given below for the duty cycle at which the welder will be operated.

Duty Cycle (per cent)	50	40	30	25	20	15	10	7.5	5.0 or less
Multiplier	.71	.63	.55	.50	.45	.39	.32	.27	.22

B. *Groups of Welders.* The rated current-carrying capacity of conductors which supply two or more welders shall be not less than the sum of the value obtained as explained in paragraph A of this order for the largest welder supplied, and 60 per cent of the values obtained as explained in paragraph A of this order for all the other welders supplied.

C. *Explanation of Terms.* (1) The rated primary current is the rated kva multiplied by 1,000 and divided by the rated primary voltage, using values given on the name-plate. (2) The actual primary current is the current drawn from the supply circuit during each welder operation at the particular heat tap and control setting used. (3) The duty cycle is the percentage of the time during which the welder is loaded. For instance, a spot welder supplied by a 60-cycle system (216,000 cycles per hour) making four hundred 15-cycle welds per hour would have a duty cycle of 2.8 per cent. (400 multiplied by 15, divided by 216,000, multiplied by 100). A seam welder operating 2 cycles "on" and 2 cycles "off" would have a duty cycle of 50 per cent.

Order 13-6332. Overcurrent Protection.

Overcurrent protection shall be as provided in paragraphs A and B of this order. If the nearest standard rating of the overcurrent device used is under the value specified in this order, or if the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher rating or setting may be used.

A. *For Welders.* Each welder shall have an overcurrent device rated or set at not more than 300 per cent of the rated primary current of the welder, except that an overcurrent device is not required for a welder having a supply circuit protected by an overcurrent device rated or set at not more than 300 per cent of the rated primary current of the welder.

B. *For Conductors.* Conductors which supply one or more welders shall be protected by an overcurrent device rated or set at not more than 300 per cent of the conductor rating.

Order 13-6333. Disconnecting Means.

A switch or circuit-breaker shall be provided by which each welder and its control equipment can be isolated from the supply circuit. The current-carrying capacity of this disconnecting means shall be not less than the supply conductor rating determined as explained in this section. The supply circuit switch may be used as the welder disconnecting means if the circuit supplies only one welder.

Order 13-6334. Name-plate.

A name-plate giving the following information shall be provided: name of manufacturer, frequency, primary voltage, rated kva at 50 per cent duty cycle, maximum and minimum open-circuit secondary voltage, short-circuit secondary current at maximum secondary voltage and specified throat and gap setting.

SECTION 13-640. SOUND RECORDING AND SIMILAR EQUIPMENT

Order 13-6401. Scope.

This section shall apply to installations of equipment and wiring used for sound recording and reproduction, centralized distribution of sound, public address, speech-input systems and electronic organs.

Order 13-6402. Application of Other Sections.

Except as modified by this section, wiring and equipment from source of power to and between devices connected to the interior wiring systems shall comply with the requirements of Chapters 1 to 4, inclusive, of this code, and wiring and equipment for public-address, speech-input, radio-frequency, audio-frequency systems, and amplifying equipment associated with radio receiving stations in centralized distribution systems, shall comply with Section 13-725.

Order 13-6403. Number of Conductors in Raceway.

The number of conductors in a conduit or other raceway shall comply with Tables 4 to 11 of Chapter 10 except as follows:

A. Special permission may be granted for the installation of two 2-conductor lead covered cables in ¾ inch conduit, provided the cross sectional area of each cable does not exceed .11 square inch.

B. Special permission may be granted for the installation of two 2-conductor No. 19 lead covered cables in ½ inch conduit, provided the sum of the cross sectional areas of the cables does not exceed 32 per cent of the internal cross sectional area of the conduit.

Order 13-6404. Wireways and Auxiliary Gutters.

Wireways and auxiliary gutters shall comply with the requirements of Sections 13-362 and 13-374 with the following exceptions where used for sound recording and reproduction:

A. *Number of Conductors in Raceway.* Conductors in wireways or gutters shall not fill the raceway to more than 75 per cent of its depth.

B. *Auxiliary Gutter Covers.* If the cover of auxiliary gutters is flush with the flooring and is subject to the moving of heavy objects it shall be of steel at least ¼ inch in thickness; if not subject to moving of heavy objects, as in the rear of patch or other equipment panels, the cover shall be at least No. 10 USS gauge (.1345 inch).

C. *Metal Trough Raceways.* Metal trough raceways may be installed in concealed places if run in a straight line between outlets or junction boxes. Covers of boxes must be accessible. Edges of metal must be rounded at outlet or junction boxes and all rough projections smoothed to prevent abrasion of insulation or conductors. Raceways made of sections shall be bonded and grounded as prescribed in Order 13-2575.

D. *Grounding Wireways and Auxiliary Gutters.* Metal wireways and auxiliary gutters shall be grounded in accordance with the requirements of Section 13-250. If the wireway or auxiliary gutter does not contain power supply wires, the grounding conductor need not be larger than No. 14 copper or its equivalent. If the wireway or auxiliary gutter contains power supply wires, the grounding conductor shall not be smaller than the size called for in Order 13-2595.

Order 13-6405. Grouping of Conductors.

Conductors of different systems grouped in the same conduit or other metallic enclosure, or in portable cords or cables, shall comply with the following requirements:

A. *Power Supply Conductors.* Power supply conductors shall be properly identified and shall be used solely for supplying power to the equipment to which the other conductors are connected.

B. *Leads to Motor Generator or Rotary Converter.* Input leads to a motor generator or rotary converter shall be run separately from the output leads.

C. *Conductor Insulation.* The conductors shall be insulated individually, or collectively in groups, by insulation at least equivalent to that on the power supply and other conductors, except where the power supply and other conductors are separated by a lead sheath or other continuous metallic covering.

D. *Flexible Cords.* Flexible cords and cables shall be of Types P, K, S, SJ, SO or SUO or other types specifically approved for the purpose for which they are to be used. The conductors of flexible cords, other than power supply conductors, may be of a size not smaller than No. 26 provided such conductors are not in direct electrical connection with the power supply conductors and are equipped with current limiting means so that the maximum power under any condition will not exceed 150 watts.

E. *Terminals.* Terminals shall be marked to show their proper connections. Terminals for conductors other than power supply conductors shall be separated from the terminals of the power supply conductors by a spacing at least as great as the spacing between power supply terminals of opposite polarity.

Order 13-6406. Storage Batteries.

Storage batteries shall comply with the following:

A. *Installation.* Storage batteries shall be installed in accordance with Section 13-480.

B. *Conductor Insulation.* Storage battery leads shall be rubber or thermoplastic covered.

C. *Overcurrent Protection.* Overcurrent protection shall be provided as follows:

1. "A" circuit, when supplied by branch lighting circuits, or by storage batteries of more than 20 ampere hour capacity, shall have overcurrent protection not exceeding 15 amperes.

2. "B" circuits shall have overcurrent protection not exceeding 1 ampere. The overcurrent protection shall be placed in each positive lead.

3. "C" circuits when supplied from branch lighting circuits or from storage batteries of more than 20 ampere-hour capacity shall have overcurrent protection not exceeding one ampere.

4. Overcurrent devices shall be located as near as practicable to the battery.

Order 13-6407. Equipment.

Amplifiers and rectifiers shall be so located as to be readily accessible. They shall be suitably housed and shall be of a type approved for the purpose unless otherwise expressly permitted by the authority enforcing this code. Equipment used in hazardous locations shall be specifically approved for the purpose.

A. *Ventilation.* Amplifiers and rectifiers shall be so located as to provide sufficient ventilation to prevent undue temperature rise within the housing.

B. *Protection Against Mechanical Injury.* Amplifiers, rectifiers, loud-speakers and other equipment shall be so located or protected as to guard against mechanical injury such as might result in fire or personal hazard.

SECTION 13-650. ORGANS

Order 13-6501. General.

This section shall apply to those electric circuits and parts of electrically operated organs which are employed for the control of the sounding apparatus and keyboards. Electronic organs shall comply with the appropriate provisions of Section 13-640.

Order 13-6502. Source of Energy.

The source of energy shall be a self-excited generator of not over 15 volts, or a primary battery.

Order 13-6503. Insulation—Grounding.

The generator shall be effectively insulated from the ground and from the motor driving it, or both the generator and the motor frames shall be grounded in the manner prescribed in Section 13-250.

Order 13-6504. Conductors.

Conductors shall comply with the following:

A. *Size.* No conductor shall be smaller than No. 26, and the common return conductor shall be not smaller than No. 14.

B. *Insulation.* Conductors shall have rubber, thermoplastic, asbestos, cotton, or silk insulation, except the common-return conductor

which shall be rubber-covered, thermoplastic, asbestos-covered (Types AA, AI, or AIA), or slow-burning (Type SB). The cotton or silk may be saturated with paraffine if desired.

C. *Conductors to Be Cabled.* Except the common return conductor, and conductors inside the organ proper, the organ sections and the organ console, conductors shall be cabled. The common return conductor may be placed under an additional covering enclosing both cable and return conductor, or may be installed as a separate conductor and may be in contact with the cable.

D. *Cable Covering.* The cable shall be provided with one or more braided outer coverings, provided that a tape may be used in place of an inner braid. Unless installed in metal raceways the outer braid shall be flame-retardant or shall be covered with a closely wound fireproof tape.

Order 13-6505. Installation of Conductors.

Cables shall be securely fastened in place and may be attached directly to the organ structure without insulating supports. Cables shall not be placed in contact with other conductors.

Order 13-6506. Overcurrent Protection.

Circuits shall be so arranged that all conductors, except the main supply conductors and the common return conductor, shall be protected from overcurrent by an overcurrent device of not greater than 15 ampere rating.

SECTION 13-660. X-RAY AND HIGH FREQUENCY EQUIPMENT

Order 13-6601. Scope.

The provisions of this section shall apply to all apparatus embodying X-ray operating at any frequency, for medical use, for examination of fabrics, metals, or fruits, or for any other purpose. Unless approved for the location, X-ray and related apparatus shall not be installed nor operated in hazardous locations or operated on a supply potential of more than 600 volts.

Nothing in this section shall be construed as specifying safeguards against direct, stray or secondary X-ray radiation. Such safeguarding for industrial installations is the scope of Parts I and III of American War Standard ASA Z-54.

Order 13-6602. Overhead Conductors.

For new equipment used on new installations of X-ray apparatus, all conductors in the high-voltage circuits that are not in raceways shall be of the approved shockproof type. When existing equipment employing uninsulated or bare overhead conductors is moved to a new location, or where reconditioned used equipment of the uninsulated or bare conductor overhead type is resold for installation at a new location, the authority enforcing this code may require that the overhead stationary conductors be not less than 8 feet from the floor

unless guarded from contact, and that any connections from the X-ray tube to exposed overhead uninsulated or bare conductors shall be made with high-voltage cables of the approved shockproof type.

Order 13-6603. On Fluoroscope Tables.

Leads on fluoroscope tables shall be adequately insulated or be provided with barriers which will guard against inadvertent contact.

Order 13-6604. Milliammeter.

If one side or mid-point of the high voltage circuit is grounded, the milliammeter shall be connected to the grounded lead and need not be guarded.

Order 13-6605. Wiring Terminals.

Equipment covered by this section shall be provided with suitable wiring terminals or leads for the connection of conductors of at least the size required by the load corresponding to the input rating of the equipment.

Order 13-6606. Connection to Supply Circuit.

X-ray apparatus permanently installed shall be connected to the power supply by means of a wiring method meeting the general requirements of this code, except that apparatus properly supplied by branch circuits not larger than a 30-ampere branch circuit may be supplied through suitable plug and heavy-duty cable or cord. Transportable X-ray apparatus of any capacity may be connected to its power supply by suitable temporary connections and heavy-duty cable or cord. A disconnecting means of adequate capacity shall be provided in a location readily accessible from the X-ray control. For apparatus requiring 115-volt line fuses of 30 ampere or less a plug and receptacle of proper size and of an approved make may serve as a disconnecting means.

CONTROL

Order 13-6611. Stationary Equipment.

The low-voltage circuit of the step-up transformer shall contain a circuit-breaker having no exposed live parts and which shall under all operating conditions protect the radiographic circuit against fault conditions. If the design of the high-voltage transformer is such that branch fuses having a current rating lower than the current rating of the circuit-breaker are required for adequate protection for fluoroscopic and therapeutic circuits, they shall be added for the protection of these circuits. It is recommended that, if possible, the circuit-breaker protect all circuits; namely, radiographic, fluoroscopic and therapeutic circuits. The circuit-breaker shall be installed as a part of the equipment or directly adjacent thereto. The circuit-breaker shall be manually operable, or else there shall be at least one other switch which is manually operable in the low-voltage circuit of the step-up transformer, either as a part of the equipment or directly adjacent thereto.

Order 13–6612. Portable Equipment.

Portable equipment shall comply with Order 13–6611, except that no circuit-breaker is required when the high-voltage parts, including the X-ray tube, are within the single metallic enclosure which is provided with a means for grounding. The circuit-breaker, when required, shall be located in or on the portable equipment.

Order 13–6613. General.

In addition to complying with Orders 13–6611 or 13–6612 as the case may be, medical X-ray apparatus shall be provided with controlling means as follows:

A. *Radiographic Type.* A timer shall be provided and controlled by a switch which shall be designed to open automatically except when held closed by the operator.

B. *Fluoroscopic Type.* A switch shall be provided which shall be designed to open automatically except when held closed by the operator.

C. *Therapy.* A timer shall be provided which is not of the repeating type.

Order 13–6614. Industrial X-ray Apparatus.

Radiographic and Fluoroscopic Types. A switch which shall be designed to open automatically except when held closed by the operator, or a timer, shall be provided.

Order 13–6615. Foot Switch.

Switches operated by foot pressure should be provided with a shield over the contact button to avoid accidental closing unless the equipment is of the fully enclosed shockproof type. When used for radiographic work, the foot switch shall return automatically to the X-ray off position when foot pressure is removed. The foregoing recommendation shall have mandatory effect in the case of X-ray equipment for industrial use.

Order 13–6616. Independent Control.

If more than one piece of apparatus is operated from the same high-voltage circuit, each piece or each group of apparatus as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact with its live parts.

TRANSFORMERS AND CAPACITORS

Order 13–6621. General.

Transformers and capacitors which are a part of an X-ray apparatus shall not be required to conform to the requirements of Sections 13–450 and 13–460.

Order 13–6622. Draining Capacitor Charge.

Unless all current-carrying parts of capacitors, and of the conductors connected therewith, are at least 8 feet from the floor and are

inaccessible to unauthorized persons, or unless when within 8 feet from the floor are within enclosures of grounded metal or insulating material, capacitors shall be provided with an automatic means for discharge and grounding the plates whenever the transformer primary is disconnected from the source of supply.

GUARDING

Order 13–6631. General.

For new apparatus used on new installations, all high-voltage parts shall be mounted within grounded enclosures. Either air, oil, or other suitable insulating media may be used to insulate the high voltage from the grounded enclosure. When existing apparatus employing open type overhead conductors is moved to a new location, or where reconditioned used apparatus of the open overhead type is resold for installation at a new location, the authority enforcing this code may require that all high-voltage parts within 8 feet of the floor be protected against contact by barriers of grounded metal, or protected by approved insulating material. These requirements do not apply if the high-voltage parts are installed in separate rooms or enclosures which are provided with suitable door-operated switches to open the supply circuit to the X-ray unit except while the door of such room or enclosure is locked from the outside. The connections from the exposed overhead conductors may be made with high-voltage cables of the shockproof type.

Order 13–6632. Enclosures of Wood.

Wooden cabinets containing high voltage parts shall be lined inside with approved fire resistive material. The high voltage parts shall have adequate spacing from walls of the cabinet. High voltage equipment containing oil shall not be installed in wooden cabinets. Cabinets shall provide sufficient ventilation for safe operation of the equipment therein.

Order 13–6633. Therapy Tubes and Equipment.

X-ray tubes used in therapy shall be mounted in enclosures of grounded metal or insulating material approved for the purpose unless otherwise expressly permitted by the authority enforcing this code. Unless fully enclosed in cabinets or cases of grounded metal or of approved insulating materials, all high voltage parts of generators, rectifiers, filters and cooling equipment shall be installed in a separate room or enclosure. Suitable arrangements shall be provided whereby the switch controlling the supply circuit to such equipment will necessarily be open, except while the door of such room or enclosure is locked from the outside.

Order 13–6634. Grounding.

Non-current-carrying metal parts of tube stands, fluoroscopic and other apparatus shall be grounded in the manner prescribed in Section 13–250.

SECTION 13-665. INDUCTION AND DIELECTRIC HEAT GENERATING EQUIPMENT

Order 13-6651. Scope.

The provisions of this section shall apply to the construction and installation of induction and dielectric heat-generating equipment and accessories.

The term "generating equipment" as used in this section shall be understood to mean any equipment used to change the voltage and/or frequency of the power supplied to such equipment.

Induction heating is the heating of a nominally conducting material due to its own I^2R losses when the material is placed in a varying electro-magnetic field.

Dielectric heating is the heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

The term "therapeutic high frequency equipment" as used in this section shall be understood to mean generating equipment capable of producing alternating currents having frequencies greater than those frequencies which elicit neuromuscular response. In order to comply with the above, the output frequency of the therapeutic high frequency equipment shall not be less than 2 megacycles.

Order 13-6652. Application of Other Sections.

Wiring from the source of power to generating equipment shall comply with Code Chapters 1 to 4 inclusive. Circuits and equipment operating on a supply circuit of more than 600 volts shall comply with the provisions of Section 13-710.

Order 13-6653. Capacity of Supply Conductors.

A. *For Motor Generator Equipment.* Capacity of supply conductors shall be determined from Section 13-430 of this Code.

B. *For Other Than Motor Generator Equipment.* Capacity of supply conductors shall be determined as follows:

1. The current-carrying capacity of the circuit shall be at least 100 per cent of the nameplate current rating of the equipment.

2. The current-carrying capacity of conductors supplying two or more equipments shall be equal to at least 100 per cent of the sum of nameplate current ratings on all equipment involved except as follows: If, when supplying two or more equipments from the same feeder, simultaneous operation of said equipments is not possible, the capacity of the feeder shall be at least 100 per cent of the sum of the nameplate currents for the largest group of machines capable of simultaneous operation, plus 100 per cent of the standby currents of the remaining machines supplied.

Order 13-6654. Overcurrent Protection.

A. *For Motor Generator Equipment.* Overcurrent protection shall be provided as specified in Section 13-430 of this Code.

B. *Other Than Motor Generator Equipment.* Overcurrent protection shall be provided, if not supplied as part of the equipment, to protect the equipment as a whole. The overcurrent device shall have a rating or setting of not more than 200 per cent of the nameplate current rating.

Order 13-6655. Disconnecting Means.

A readily accessible disconnecting means shall be provided by which each generating equipment can be isolated from the supply circuit. The current-carrying capacity of this disconnecting means shall be at least 100 per cent of the nameplate current rating of equipment. The supply circuit switch may be used as the generating equipment disconnecting means if the circuit supplies only one equipment.

Order 13-6656. Output Circuits.

Output circuits shall conform to the following:

A. Output circuit parts shall include all high frequency components external to the generator, including interconnecting radio frequency transmission lines, load tuning networks, and work applicators. With respect to guarding, all such parts shall be considered with the generating equipment as a complete assembly.

B. The work applicator shall be so guarded that safe operation of the equipment will always be assured.

C. When the connections between the generator and work applicator exceed two feet in length the connections shall be enclosed or guarded with non-combustible material.

D. The generator output shall be at direct-current ground potential (coupled outputs alone, without other precautions, will not suffice because of the danger existing during possible flashovers).

Order 13-6657. Grounding and Bonding.

Grounds or inter-unit bonding shall be used wherever required for circuit operation and for limiting to a safe value radio frequency potentials between all exposed non-current-carrying parts of the equipment and earth ground, also between all equipment parts and surrounding objects and between such objects and earth ground. Such grounding and bonding shall be installed in accordance with Section 13-250 of this Code.

Order 13-6658. Low Frequency A.C. in Generating Equipment Output.

Commercial frequencies of 25 to 60 cycle alternating-current output may be coupled for control purposes, but shall be limited to a value of 150 volts available only during periods of circuit operation.

Order 13-6659. Hazardous Locations.

Induction and dielectric heat generating equipment shall not be installed in hazardous locations as defined in Section 13-500 unless the equipment is designed and approved for hazardous locations.

Order 13-6660. Enclosure of Generating Apparatus.

The generating apparatus including the D.C., low-, and high-frequency electrical circuits but excluding the output circuits shall be completely contained in an enclosure of noncombustible material. The metal housings of motors, generators and the like may serve as a part of this enclosure.

Order 13-6661. Panel Controls.

All panel controls shall be of "dead front" construction.

Order 13-6662. Access to Internal Equipment.

Doors or detachable panels may be employed for internal access. Where doors are used, giving access to voltages above 500 volts A.C. or D.C., either door locks shall be provided or interlocking shall be installed with the choice of precaution optional. Detachable panels not normally used for access to such parts shall be fastened in a manner not conveniently removable.

Order 13-6663. Warning Labels.

Warning labels, definitely indicating danger, shall be attached to doors, access panels or at other vantage points on equipment, so that the labels will be plainly visible when doors are opened or panels are removed from compartments containing voltages above 250 volts A.C. or D.C.

Order 13-6664. Foot Switch.

Switches operated by foot pressure shall be provided with a shield over the contact button to avoid accidental closing.

Order 13-6665. Nameplate Data.

Each generating equipment shall be provided with a nameplate giving the manufacturers' name and model identification and the following input data: line volts, frequency, number of phases, maximum current, full load kva, and power factor.

Order 13-6666. Remote Control.

When remote controls are used for applying power, a "Local-Remote" switch shall be provided and interlocked so as to prevent the possibility of applying power from other than one selected control point or points.

Order 13-6667. Capacitors.

When capacitors in excess of 0.1 Mfd. are used in D.C. circuits, either as rectifier filter components, arc suppressors, etc., having circuit voltages exceeding 230 volts above ground, bleeder resistors or grounding switches shall be used as grounding devices.

Where auxiliary rectifiers are used with filter capacitors in the output for bias supplies, tube keyers, etc., bleeder resistors shall be used even though the D.C. voltage may not exceed 230 volts.

Order 13-6668. Keying.

Where high speed keying circuits dependent on the effect of "oscillator blocking" are employed, the peak RF output voltage during the blocked portion of the cycle shall not exceed 100 volts.

Order 13-6669. Protective Cages and Shielding.

Protective cages or adequate shielding shall be used to guard work applicators. Interlock switches shall be used on all hinged access doors, sliding panels or other easy access means normally intended for quick access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open.

Order 13-6670. Power Supply for Therapeutic Equipment.

A. Where portability is not essential, equipment shall be permanently installed in accordance with Chapters 1 to 3 inclusive.

B. Where portability is essential, the power supply cord shall be three-conductor hard service cord of such current-carrying capacity as to be not less than the marked rating of the equipment, and it shall be provided with one conductor whose insulation is green in color for equipment grounding. If the marked rating of the equipment exceeds 15 amperes the cord shall terminate in an approved three-blade attachment-plug cap. If the marked rating of the appliance does not exceed 15 amperes the cord may be terminated in an approved two-blade attachment-plug cap with grounding wire. (See Order 13-2559)

Order 13-6671. Applicators for Therapeutic Equipment.

Application of the high frequency power to the patient may be made by means of an electric field or of an induction field. Current-carrying parts of applicators shall be so insulated or enclosed that reliable isolation of the patient shall be assured.

SECTION 13-670. MACHINE TOOLS

GENERAL

Order 13-6701. Scope.

The provisions of this section apply to the electrical equipment for motor-driven, complete metal working machines, not portable by hand, having one or more tool and work holding devices used for progressively removing metal in the form of chips.

Order 13-6702. Application of Other Sections.

The following provisions cover the requirements for electrical wiring and equipment on machine tools within the scope of this section. They are in addition to or amendatory of the applicable provisions of other sections of this code, which apply except as modified in this section.

Order 13–6703. Identification.

Each electrically operated machine tool shall be marked where plainly visible to show the voltage, full-load current and frequency required for each external circuit supplying the machine tool. For a multi-motored machine tool, this full-load current marking shall be not less than the sum of the full-load currents required for all motors which may be in operation at one time under normal conditions of use. If only a single motor is used, the motor nameplate may serve if plainly visible.

Order 13–6704. Lighting.

Lighting fixtures which are a part of or attached to any machine tool shall conform to the following:

A. *Voltage.* The lighting circuit voltage shall not exced 150 volts between conductors and shall be a grounded circuit.

B. *Flexible Cord.* Flexible cord if used shall be of a type suitable for hard usage (see Table 31), and shall be resistant to coolant and oil. It shall be arranged so it cannot be damaged by moving parts of the machine.

WIRING METHODS

Order 13–6711. Conduit.

Conductors shall be in rigid metal conduit or electrical metallic tubing except as provided in Orders 13–6712 to 13–6714, inclusive.

Order 13–6712. Flexible Metal Conduit.

Flexible metal conduit including the liquid tight type may be used only where necessary to employ flexible connections for small or infrequent movements, as at motor terminals.

Order 13–6713. Continuously Moving Parts.

Wiring connections to continuously moving parts of a machine tool shall be of approved type, extra-flexible, non-metallic-covered, multiconductor cable. Conductors shall conform to Order 13–6722. In lieu of cable, individual conductors enclosed in flexible tubing may be used. The tubing and its fittings shall be approved for the purpose, and conductors in such tubing shall be considered as subject to oil or coolant.

Order 13–6714. Compartments and Raceways.

Compartments and raceways within the framework of a machine tool may be used to enclose conductors, provided they are isolated from coolant and oil reservoirs and are entirely enclosed. Conductors in machine compartments and raceways shall be secured and so arranged that they will not be subject to mechanical injury or abrasion.

Order 13–6715. Number of Bends in Conduit.

If a run of rigid metal conduit does not exceed 25 feet in length, and the conductor fill does not exceed 30 per cent of the cross sectional area of the conduit, the requirements of Order 13–3471 shall not apply.

CONDUCTORS

Order 13–6721. Sizes Permitted.

Circuit and control conductors on or in machines shall not be smaller than No. 14 except as follows:

A. *Conductors to Moving Parts.* Copper conductors for control purposes to continuously moving parts may be No. 16 if all such conductors are insulated for the maximum voltage of any conductor in the cable or tubing.

B. *Conductors to Electronic and Precision Devices.* Copper conductors to electronic and precision devices may be No. 20, except if pulled into raceways they shall be not smaller than No. 18.

Order 13–6722. Type.

Conductors shall be of a type suitable for conditions of use. Flexible, non-metallic, multi-conductor cable shall have an oil- and moisture-resistant insulation with a flame-retardant outer covering.

Order 13–6723. Identification of Conductors.

Conductors shall be identified either by color code or by other distinctive means. White or natural gray coloring shall be used only for a grounded conductor, and green only for a conductor used to ground the frame of equipment.

CONTROL EQUIPMENT

Order 13–6731. Mounting.

Controllers shall be mounted in such a manner as to guard against mechanical injury, oil, coolant, dust, and dirt.

Order 13–6732. In Machine Compartments.

Compartments in the column or base of a machine may serve as enclosures for control equipment if the following provisions are complied with:

A. *Thickness of Metal.* The wall thickness shall be not less than No. 14 USS sheet metal gauge if of sheet steel, not less than ⅛ inch if of cast metal, or not less than $\frac{3}{32}$ inch if of malleable iron.

B. *Covers.* Compartments shall have tight fitting hinged covers, not thinner than specified in paragraph A. Covers shall have adequate means for fastening securely in a closed position.

C. *Control Enclosures.* Compartments used for control enclosures shall be readily accessible and shall not contain moving parts not directly connected to electrical control equipment, and shall be so located as to guard the control devices against oil, coolant, chips, and dirt.

D. *Venting.* A compartment enclosing group control equipment with branch circuit fusing as specified in paragraph B of Order 13–6742

shall have a clear opening of at least 2 square inches, vented to another compartment within the column or base and having at least one-half the volume of the control compartment.

E. *No Floor Opening.* Compartments enclosing control equipment shall not be open to the floor or foundation upon which the machine rests.

Order 13–6733. Not In Machine Compartment.

Controllers not in machine compartments shall comply with the following:

A. Controllers with overcurrent protection as permitted by Order 13–6742 may be mounted on the outside of the machine tool or on the floor as close to the machine tool as possible provided the enclosures comply with all the provisions of Order 13–6732.

B. Other controllers may be mounted on the outside of the machine tool or elsewhere if they comply with the provisions of Section 13–430.

MOTOR BRANCH-CIRCUIT OVERCURRENT PROTECTION

Order 13–6741. Branch Circuits.

Any motor on a machine tool may be supplied from an individual branch circuit in accordance with the provisions of Section 13–430, or may be connected to a branch circuit which also supplies other motors on the same machine tool in accordance with the provisions of Order 13–4343 or of Order 13–6742. The conductors supplying all motors on a single machine tool may be considered a single branch circuit if all of these motors are protected in accordance with the provisions of Order 13–4343 or of Order 13–6742.

Order 13–6742. Several Motors on One Branch Circuit.

Controllers and running overcurrent protective devices for two or more motors connected to the branch circuit of a single machine tool need not comply with the provisions of Order 13–4343, if all of the following provisions are complied with:

A. *Motor-Running Protection.* Each motor shall be protected by a motor-running overcurrent protective device.

B. *Rating of Overcurrent Devices.* The branch circuit shall have overcurrent protection of a rating equal to that specified in Order 13–4342 for the largest motor connected to the circuit, plus an amount equal to the sum of the full-load current ratings of all other motors on the machine tool which may be in operation at one time under normal conditions of use and which are connected to the same circuit. In no case shall overcurrent protection be more than 200 amperes at 250 volts or less, or 100 amperes at 600 volts or less.

C. *Enclosures.* Enclosures for control equipment and running protective devices enclosed in machine compartments, or mounted on or

adjacent to the machine, shall comply in all respects with the provisions of Orders 13–6732 or 13–6733.

D. *Conductors.* The conductors of the branch circuit shall comply with the provisions of paragraph B of Order 13–4343.

PROTECTION AND GROUNDING

Order 13–6751. Protection Against Damage.

If the failure of one motor to operate while others continue to run could cause damage, they shall be so connected that the tripping of any overload or under-current device will result in stopping all of these motors.

Order 13–6752. Grounding.

All machine tools within the scope of this section, including connected portable equipment shall be effectively grounded as specified in Section 13–250.

Order 13–6753. Moving Parts.

A machine part that moves on grounded metal guides or supporting ways shall be considered as adequately grounded if the movable part may not readily be removed by hand.

SECTION 13–690. TRAILERS

Order 13–6901. Wiring in Trailer.

The wiring in a trailer used as a permanent residence which is to be connected to a regular outside distribution system should conform to the appropriate orders in this code.

Order 13–6902. Connection of Trailer.

Whenever a trailer is parked and its wiring system connected to the regular distribution system, proper fusing and grounding shall be provided. The acceptable means of supplying this protection is as follows:

For each trailer an outlet and conductors shall be provided for the connection of the trailer wiring system. The outlet and conductors on the regular distribution system shall consist of a fused switch, fused only on the ungrounded wire, approved receptacle, cable for supplying the energy, and a separate insulated conductor for grounding purposes. The cable and ground conductor shall be of approximately the same length. The ground conductor shall be attached to ground and to the neutral wire at the outlet and provided with a means of attaching to the trailer frame.

Note. Cable should be not over 20 feet in length and conductors should be at least No. 14 A.W.G.

Chapter 7. Special Conditions

SECTION 13-700. EMERGENCY LIGHTING

Order 13-7001. Where Required.

The provisions of this section shall apply to systems or circuits for supplying emergency illumination only when such systems or circuits are required elsewhere in this code or by municipal, state, (such as Building, School Lighting or Industrial Lighting) or other codes. See Order 13-5202.

Note. See the National Fire Protection Association Building Exits Code for other recommendations.

The methods of supplying exit and emergency illumination in existing buildings will be determined in each individual case.

Order 13-7002. Systems of Less Than 50 Volts.

If a source of supply at less than 50 volts is employed as one of the systems, the installation shall also comply with the provisions of Section 13-720 of this code.

Order 13-7003. Scope.

Emergency lighting shall include all required exit lights and all other lights specified as necessary to provide sufficient illumination to enable persons to see their way out of the building.

Order 13-7004. Tests and Maintenance.

Systems shall be operated and tested frequently enough to assure their maintenance in proper operating condition, and batteries shall be maintained in fully charged condition.

It is recommended that inspection authorities having jurisdiction conduct a test on the complete system upon installation and perodically afterward.

CURRENT SUPPLY

Order 13-7011. Source.

Current supply shall be such that in event of emergency within the building or group of buildings concerned, emergency lighting shall be available. Services may comprise:

A. One service, and a storage battery of sufficient capacity to supply and maintain at not less than 91 per cent full voltage the total load of the circuits carrying lights for emergency illumination for a period of at least ½ hour. Automobile batteries, or lead batteries of other than the sealed, glass-jar type, are not considered suitable.

B. One service and a generator set, driven by some form of prime mover and of capacity sufficient to supply circuits carrying emergency illumination load, with suitable means for automatically starting the generator on failure of the normal service.

C. Services as widely separated, electrically and physically, as the available facilities allow.

D. Connection on supply side of the main service if sufficiently separated from main service to prevent simultaneous interruption of supply through an occurrence within the building or group of buildings served.

Note. Separation shall be by walls or clear spaces and to an extent that will prevent simultaneous interruption of supply through an occurrence within the building.

It is recommended that where available, and in such locations as hospital operating rooms, separate and individual services be required for emergency lighting.

Order 13-7012. Derangement Signals.

Audible and visual signal devices shall be provided, where possible, to give warning of derangement of emergency illumination current sources jeopardizing their proper functioning, and to indicate when batteries or generator sets are carrying the emergency illumination load.

CIRCUITS

Order 13-7021. Provision for Lights.

Lights shall be provided and so located and supplied as to provide, with one service interrupted, emergency illumination without appreciable delay. The installation of lights would ordinarily require either one of the following:

A. An emergency lighting system, independent of the general lighting system, with provisions for automatically transferring, by means of devices approved for the purpose, the emergency system from a defective supply to another supply.

B. Two or more separate and complete systems with independent current supply each providing emergency lighting. Unless both systems are kept lighted, means shall be provided for automatically lighting either system upon failure of the other. Either or both systems may be a part of the general house lighting system if circuits carrying lights for emergency illumination are installed in accordance with other orders of this section.

Order 13-7022. Independent Wiring.

Wiring shall be kept entirely independent of all other wiring and equipment and shall not enter the same fixture, raceway, box or cabinet with other wiring except as permitted in sub-paragraph B of Order 13-7021.

Order 13-7023. Connection of Appliances.

No appliances or lamps, other than those specified as required for emergency illumination, shall be supplied by such circuits except as provided in sub-paragraph B of Order 13-7021.

CONTROL

Order 13–7031. Switch Required.

Circuits for emergency illumination shall be controlled through one switch accessible only to authorized persons.

Order 13–7032. Location.

This switch shall be located preferably in the lobby; otherwise at a place convenient to the main entrance to the building, but in no case in a booth for projection of motion pictures.

Order 13–7033. Other Switches.

In addition to the above switch, there may be:

A. A switch at the main service or on the control panel of a special current source.

B. A switch located adjacent to the emergency switch, or an automatic light actuated device approved for the purpose, to control separately those lights on the exterior of the building which are not required for illumination when there is sufficient daylight.

Order 13–7034. Stage Control Prohibited.

Circuits shall not be connected to or controlled by a stage lighting control.

OVERCURRENT PROTECTION

Order 13–7041. Service.

Service overcurrent devices only may be placed ahead of the branch-circuit overcurrent devices.

Order 13–7042. Accessible Only to Authorized Persons.

The branch-circuit overcurrent devices shall be accessible to authorized persons only.

SECTION 13–710. CIRCUITS AND EQUIPMENT OPERATING AT MORE THAN 600 VOLTS BETWEEN CONDUCTORS

Order 13–7101. General.

This section shall apply to installations operating at more than 600 volts between conductors. See Order 13–0001–B.

Order 13–7102. Application of Other Sections.

Except as modified by this section, services of more than 600 volts shall conform to Orders 13–2301 to 13–2325, inclusive; Order 13–2335, 13–2381, 13–2382, and Orders 13–2387 to 13–2392, inclusive; lighting fixtures shall conform to Section 13–410; motors shall conform to Section 13–430; transformers shall conform to Section 13–450; capacitors shall conform to Section 13–460; electric discharge signs shall conform to Section 13–600; X-ray equipment shall conform to Section 13–660; and outside wires shall conform to Section 13–730.

Order 13–7103. Insulation and Interrupting Capacity.

Conductors, devices and equipment shall have an insulation or separation between parts of different potential and between live parts and the ground, sufficient for the particular voltage employed. Interrupting devices shall have an interrupting rating at the circuit voltage sufficient for the voltage and current employed.

Order 13–7104. Constant-Current Systems.

Elsewhere than in substations and transformer vaults, constant-current systems shall not be installed in buildings, and lamps or fixtures on series circuits shall not be attached to exterior of building walls unless the walls are of fire-resistive construction.

INSTALLATION OF CONDUCTORS

Order 13–7111. Wiring Method.

Except in generator, transformer, switching and motor rooms, and for service runs of multiple conductor cable approved for the purpose, as permitted in Order 13–2387, conductors shall be in rigid conduit, duct, or armored cable specially approved for the voltage.

Order 13–7112. Conductor Location.

All circuits of more than 15,000 volts between conductors shall be installed only in transformer vaults, substations, and fire-resistant motor rooms, except as permitted for X-ray equipment in Section 13–660. Conductors in conduit or duct and enclosed by concrete, brick, or equivalent fire-resistant material not less than 2 inches thick shall be considered outside the building.

Order 13–7113. Open Conductors—Supports and Separation.

If open work is employed, the conductors shall be supported on insulators of glass, porcelain, or other material approved for the purpose. Open conductors shall be separated not less than 8 inches from each other, except at apparatus and devices. They shall be not less than 2 inches from the surface wired over, and for voltages exceeding 2500 not less than 3 inches. Conductors and their supports, including insulators, shall have the strength and stability to insure maintenance of the required clearance in case of short-circuit current.

Order 13–7114. Conductor Covering.

Open insulated conductors shall have a flame-retardant outer covering. The conductor covering shall be stripped back one inch from the terminals so as not to touch them. If insulated conductors are provided with a conducting or metalized shielding tape over the insulation and under the outer covering, this shielding tape shall be stripped back a safe distance for the voltage employed, a stress cone made, and the shielding tape adequately grounded at the terminals.

Order 13–7115. Lead-Covered Conductors.

Where conductors emerge from a lead sheath, they shall be protected from moisture and mechanical injury by a pothead or by

other means which will give equivalent protection. The lead sheath should be continued over splices.

Order 13–7116. Conduit to Enter Fitting.

Conduits shall enter and be secured to the casing, shields or enclosures of apparatus or to terminal boxes bolted or otherwise secured to the casing, shield, or enclosure, except in generator, transformer, switching and motor rooms and in substations.

Order 13–7117. Shielding of Rubber-Insulated Conductors.

If non-leaded, fibrous-covered, rubber-insulated conductors for permanent installation operate at voltages higher than those indicated in the following table and under the conditions mentioned, they shall be of a type having metallic or semi-conducting shielding or other construction for the purpose of confining their dielectric field. The semi-conducting shield or other construction for controlling or confining the dielectric field shall be an approved type.

Method of Installation	Voltage in Kv Above which Shielding is Required: Neutral Grounded	Neutral Ungrounded
In ducts or metal conduits in wet or damp locations	2	2
In ducts or metal conduits in permanently dry locations	6†	3†
On insulators, only if multiple conductor	6	3

†Supposedly dry metallic conduits in some cases may contain sufficient moisture to allow formation of ozone and thus damage non-shielded cable at voltages above 2000. For conservative practice it may be desirable to shield below the limits given.

This rule is necessary because of the susceptibility to damage of rubber-covered conductors by corona which occurs at the higher voltages, particularly under alternately moist and dry conditions.

Order 13–7118. Grounding of Shielding.

The shielding of shielded cable, whether of the metallic or semi-conducting type, shall be grounded, preferably at two or more points. Stress cones shall be made at all terminations of shielding, as in potheads and joints.

Ungrounded shielding normally has a potential above ground and should be regarded as a live conductor.

CONTROL

Order 13–7131. General.

Orders 13–7132 to 13–7144 shall apply only to circuits and apparatus supplied through service equipment. They shall not apply to equipment in vaults.

Order 13–7132. Separate Control.

Each transformer or bank of transformers operating as a unit, and each other operating unit of apparatus shall, except as provided in Order 13–7143, be separately controlled.

Order 13–7133. Step-Up or Step-Down Units.

If a generator operates with a transformer or a bank of transformers as a unit for stepping up or stepping down the voltage, they may be controlled as an operating unit.

Order 13–7134. Series Trip Coils.

Series trip coils connected directly to the circuit, unless guarded or isolated by elevation, should not be used with panel or panel-frame-mounted oil circuit-breakers on circuits exceeding 750 volts. It is recommended that the use, without a transformer, of series trip coils in alternating-current circuits exceeding 750 volts be avoided.

Order 13–7135. Enclosure of Apparatus.

Switches, circuit-breakers, and control apparatus on circuits exceeding 5,000 volts between conductors shall have a metal enclosure such as metal-enclosed switch-gear, trucks, and cubicles, or be installed remotely controlled in a fire-resistant switchroom or motor room or in a vault complying with Orders 13–4541 to 13–4548 inclusive.

If live parts of equipment in metal enclosures are accessible by means of a door, the door shall be provided with a lock so that it cannot be opened by unauthorized persons, or with an interlock which will prevent opening unless the parts thereby exposed are de-energized.

If connected to a circuit exceeding 15,000 volts between conductors, such apparatus shall be installed only in a vault which complies with Orders 13–4541 to 13–4548 inclusive.

Order 13–7136. Oil Circuit-Breakers and Oil Switches to be Isolated.

Oil circuit-breakers and oil switches shall be located away from other apparatus wherever practicable. If mounted in a closed compartment, means shall be provided to indicate whether the breaker is open or closed. Unless installed in dead front type, automatic disconnecting switch-gear equipment, suitable air break isolating disconnecting switches shall be installed to isolate each oil switch or oil circuit breaker from the source of supply in any case where isolation cannot be effected otherwise.

It is recommended that oil switches used to control transformers be outside the vaults containing the transformers.

Order 13–7137. Switches to Be Safely Accessible.

All switches shall be so located that the point from which they are operated is safely accessible to qualified and authorized persons. Isolating switches shall be accessible to qualified persons only. Barriers should be provided on both sides of isolating switches.

Order 13–7138. Warning Signs.

Unless isolating switches are so interlocked that they cannot be opened under load, signs shall be installed at isolating switches warning against opening them while they are carrying current.

OVERCURRENT PROTECTION

Order 13-7141. General.

Each operating unit of apparatus shall be protected from overcurrent by a manually or power operated circuit-breaker except as provided in Order 13-7143, which will interrupt all ungrounded conductors.

Order 13-7142. Number of Overcurrent Units.

The number of overcurrent units shall be as specified in Table 28, Chapter 10.

Order 13-7143. Fuses.

Fuses of suitable rating and type, which conform to Order 13-7103, may be used on circuits of not more than 15,000 volts for the following purposes:

A. For the protection of individual feeder or branch circuits at the point where they receive their supply. If there is more than one such circuit, there shall be a manually or power operated circuit-breaker between the point of origin of such circuits and the source of supply.

B. For the protection of motors as specified in Section 13-430.

C. For the protection of transformers as specified in Section 13-450.

D. For the protection of other classes of apparatus by special permission.

Order 13-7144. Injury From Fuses.

Fusible cutouts shall be so installed that the blowing of the fuse will not result in injury to persons or damage to other equipment. They shall be accessible to qualified attendants only.

MOTORS

Order 13-7151. General.

Motors operating at more than 600 volts shall comply with the provisions of Section 13-430.

SERVICES AND SERVICE EQUIPMENT

Order 13-7152. General.

Services and service equipment shall comply with Section 13-230.

TRANSFORMERS

Order 13-7153. General.

Transformers operating at more than 600 volts shall comply with the provisions of Section 13-450.

GUARDING

Order 13-7161. Live Parts to Be Guarded.

If accessible to unqualified persons, all live parts, including conductors, shall be enclosed or isolated.

Order 13-7162. Isolation by Elevation.

To secure isolation by elevation, the distances above the floor or working surface shall be not less than given in Table 32, Chapter 10.

Order 13-7163. Working Space.

Except in stations, substations and vaults, under the sole control of the supply company, adequate working space shall be provided adjacent to current-carrying parts upon which repairs or adjustments must be made while such parts are alive. The clear space when removable guards are taken away shall be not less than given in Table 33 of Chapter 10. If live parts are exposed on opposite sides of the working space, a clear space of not less than 4 feet shall be provided.

Order 13-7164. Air-Break Switches and Fuses.

Air-break isolating switches and fuses shall be accessible to qualified persons only.

Order 13-7165. Generator, Switching, and Motor Rooms to be Locked.

Generator, switching, and motor rooms shall be securely locked except while a qualified operator is present.

GROUNDING

Order 13-7171. General.

Except in stations, substations and vaults under the sole control of the supply company, enclosures of metal and all non-current-carrying parts of equipment or apparatus shall be grounded in the manner specified in Section 13-250.

SECTION 13-720. CIRCUITS AND EQUIPMENT OPERATING AT LESS THAN 50 VOLTS

Order 13-7201. General.

This section shall apply to installations operating at less than 50 volts, direct current or alternating current, except such as are treated in Sections 13-650 and 13-725.

Order 13-7202. Larger Current at Lower Voltage.

Conductors, devices, and equipment shall have current ratings sufficient for the greater current required to deliver equal power at the lower voltage than at usual voltages.

Order 13-7203. Conductors.

Conductors shall be not smaller than No. 12, and for appliance branch circuits supplying more than one appliance or appliance receptacle, conductors shall be not smaller than No. 10.

Order 13–7204. Branch Circuit.

Not more than 8 lampholders or receptacles, nor a total load of more than 320 watts, shall be connected to a branch circuit. Motors or appliances of rating more than 320 watts shall have a separate branch circuit.

Order 13–7205. Lampholders.

Standard lampholders of rating not less than 660 watts shall be used.

Note. This requirement does not apply to limited low voltage industrial lighting systems. Smaller lampholders may be used for low voltage lamps in connection with sewing machines and similar devices.

Order 13–7206. Receptacle Rating.

Receptacles shall have a rating not less than 15 amperes.

Order 13–7207. Receptacles Required.

Receptacles of not less than 20 ampere rating shall be provided in kitchens, laundries, and other locations where portable appliances are likely to be used.

Order 13–7208. Overcurrent Protection.

Overcurrent protection shall comply with the provisions of Section 13–240.

Order 13–7209. Batteries.

Batteries shall conform to the following:

A. Location. Batteries shall be located in rooms or spaces having natural ventilation.

B. Support. Battery jars and cells, if not composed of insulating material such as glass or hard rubber, shall be mounted on insulating supports of glass or porcelain.

Order 13–7210. Grounding.

Equipment and circuits shall be grounded as follows:

A. *Machines.* The grounding of frames of engines or generators is not required.

B. *Conductors.* One of the circuit conductors shall be grounded if conductors are run overhead between buildings, or if the circuit is supplied through a transformer from an ungrounded circuit or from a grounded circuit of more than 150 volts.

SECTION 13–725. REMOTE-CONTROL, LOW-ENERGY POWER AND SIGNAL CIRCUITS

Order 13–7251. Scope.

Provisions of this section shall apply to remote-control circuits, low-energy power circuits and signal circuits, as defined in Order 1020, Definitions.

The provisions of this section are not intended to apply to remote-control, low-energy or signal circuits which form an integral part of a device.

Order 13–7252. Hazardous Locations.

Circuits or equipment coming within the scope of this section and installed in hazardous locations shall also comply with the appropriate provisions of Section 13–500.

Order 13–7253. Classification.

Remote-control and signal circuits shall be classified as follows:

A. *Class 1 Circuits.* Control and signal circuits in which power is not limited in accordance with Order 13–7281.

B. *Class 2 Circuits.* Control and signal circuits in which the power is limited in accordance with Order 13–7281.

Order 13–7254. Low-Energy Power Circuits.

Circuits which are neither remote-control nor signal circuits, but which have the power limited in accordance with Order 13–7281 shall, for the purpose of this code, be treated as Class 2 remote-control circuits.

Order 13–7255. Safety-Control Devices.

Remote-control circuits to safety-control devices, the failure of operation of which would introduce a direct fire or life hazard, shall be considered as Class 1 circuits.

Room thermostats, service hot-water temperature regulating devices, and similar controls used in conjunction with electrically-controlled domestic heating equipment, are not considered to be safety-control devices.

Order 13–7256. Remote-Control and Signal Circuits in Communication Cables.

Remote-control and signal circuits, which use conductors in the same cable with communication circuits, shall, for the purpose of this section, be classified as communication circuits and meet the requirements of Section 13–800, of this code.

CLASS 1 SYSTEM

Order 13–7261. Wiring Method.

Conductors and equipment of Class 1 remote-control and signal systems shall be installed in accordance with the requirements of the appropriate sections in Chapter 3 of this code, except as provided in Orders 13–7262 to 13–7265 inclusive.

Order 13–7262. Other Sections.

The wiring method required in Order 13–7261 does not apply where other sections of this code specifically permit or require other methods for remote-control or signal circuits. See Section 13–620, Elevators, for example.

Order 13–7263. Conductor Sizes.

Nos. 18 and 16 gauge conductors may be used if installed in a raceway or a cable approved for the purpose, or in flexible cords in accordance with the provisions of Section 13–400.

Order 13–7264. Conductor Insulation.

Conductors larger than No. 16 shall be rubber-covered Type R, thermoplastic-covered Type T, or other approved type. Fixed conductors Nos. 18 and 16 gauge shall have an insulation at least equal to that of Type RF–32 rubber-covered or Type TF thermoplastic-covered fixture wire. Conductors approved for the purpose having rubber insulation of a thickness less than specified above or having other kinds of insulation may be used.

Order 13–7265. Number of Conductors in Raceways.

The number of conductors of remote-control or signal circuits in a raceway may be determined according to Tables 4 or 9 of Chapter 10; and Note 4 of Table 1 need not be observed. Where there are four or more conductors in a raceway, some of which are remote-control, as permitted by Order 13–3011, the provisions of note 4 following Tables 1 and 2 of Chapter 10 shall apply, as determined by the number of power and lighting circuit conductors only.

Order 13–7266. Conductors of Different Systems.

Conductors of two or more Class 1 remote-control and/or signal circuits may occupy the same enclosure or raceway without regard to whether the individual systems or circuits are alternating or direct current, provided all conductors are insulated for the maximum voltage of any conductor in the enclosure or raceway. Conductors of remote-control, low-energy power and signal circuits, in which the current is limited as for Class 2 systems, shall be considered as Class 1 system conductors for the purpose of this requirement if insulated and installed in accordance with the provisions for Class 1 system conductors. Power supply conductors may occupy the same enclosure or raceway with Class 1 system conductors when supplying only equipment to which Class 1 system conductors are connected.

Order 13–7267. Mechanical Protection of Remote-Control Circuits.

Where damage to a remote-control circuit would constitute a hazard as covered in Order 13–7255 all conductors of such remote-control circuits shall be installed in conduit, electrical metallic tubing or be otherwise suitably protected from mechanical injury.

Order 13–7268. Overcurrent Protection.

Conductors shall be protected against overcurrent in accordance with the carrying capacities of Tables 1 and 2, Chapter 10 except as follows:

A. *Other Sections.* Where other sections of this code specifically permit or require other overcurrent protection. See Orders 13–4372 and 13–6251.

B. *Conductors of Nos. 18 and 16.* Conductors of Nos. 18 and 16 shall be considered as protected by overcurrent devices of 15-ampere rating or setting.

C. *Omission of Overcurrent Protection.* In remote-control and signal circuits having main and branch circuits, the branch circuits need not be individually protected against overcurrent, if the operating voltage does not exceed 30 volts.

Order 13–7269. Location of Overcurrent Protection.

Overcurrent devices shall be located at the point where the conductor to be protected receives its supply unless the overcurrent device protecting the larger conductor also protects the smaller conductor in accordance with Tables 1 and 2 of Chapter 10.

Order 13–7270. Circuits Extending Beyond One Building.

Class 1 remote-control and signal circuits which extend aerially beyond one building shall also meet the requirements of Section 13–730, Outside Wiring.

Order 13–7271. Grounding.

Class 1 remote-control and signal circuits shall be grounded in accordance with Section 13–250 as follows:

A. If supplied by a separate control transformer from a system having a nominal voltage to ground of more than 150 volts.

B. If run overhead outside of buildings, and so run as to be liable to accidental contact with power conductors operating at a potential exceeding 300 volts.

LIMITATION OF CLASS 2 REMOTE-CONTROL AND SIGNAL SYSTEMS

Order 13–7281. Limitation of Class 2 Systems.

Class 2 remote-control and signal systems, depending on the voltage shall have the current limited as follows:

A. *Maximum 15 Volts: 5 Amperes.* Circuits in which the open-circuit voltage does not exceed 15 volts and having overcurrent protection of not more than 5-amperes rating. If the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, or from primary batteries, the overcurrent protection may be omitted.

B. *15 to 30 Volts: 3 Amperes.* Circuits in which the open-circuit voltage exceeds 15 volts but does not exceed 30 volts, and having overcurrent protection of not more than 3-amperes rating. If the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, or from primary batteries, the overcurrent protection may be omitted.

C. *30 to 60 Volts: 1⅓ Amperes.* Circuits in which the open-circuit voltage exceeds 30 volts but does not exceed 60 volts, and having overcurrent protection of not more than 1⅓-amperes rating. If the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, the overcurrent protection may be omitted.

D. *60 to 150 Volts: 1 Ampere.* Circuits in which the open-circuit voltage exceeds 60 volts but does not exceed 150 volts, and having overcurrent protection of not more than 1-ampere rating, provided

that such circuits are equipped with current-limiting means other than overcurrent protection which will limit the current as a result of a fault to not exceeding 1 ampere.

Order 13–7282. Overcurrent Protection and Mounting.

Where current is limited in Class 2 systems by means of overcurrent protection, such protection and its mounting shall be approved for the purpose. Overcurrent protection of different ratings shall not be of an interchangeable type. The overcurrent protection may be an integral part of a transformer or other power supply device approved for the purpose.

Order 13–7283. Transformer Rating.

Transformer devices supplying Class 2 systems shall be approved for the purpose and be restricted in their rated output to not exceeding 100 volt-amperes. They shall be marked where plainly visible to show the voltage to be applied to the circuit.

A transformer is considered as meeting the 100 volt-ampere requirement if the approximate temperature limit is reached at a 100-volt-ampere load.

INSTALLATION OF CLASS 2 REMOTE-CONTROL AND SIGNAL CIRCUITS

Order 13–7291. On Supply Side of Overcurrent Protection, Transformers or Current-Limiting Devices.

Conductors and equipment on supply side of overcurrent protection, transformers or current-limiting devices shall be installed in accordance with the appropriate requirements of Chapter 3 of this code. Transformers or other devices supplied from electric light and power circuits shall be protected by an overcurrent device with a rating or setting not exceeding 15 amperes.

Order 13–7292. On Load Side of Overcurrent Protection, Transformer or Current-Limiting Devices.

Conductors on load side of overcurrent protection, transformer or current-limiting devices shall be insulated and shall comply with the following:

A. *Separation from Other Conductors.* Conductors shall be separated from conductors of electric light and power circuits as follows:

1. Open Conductors. Conductors shall be separated at least 2 inches from any light or power conductors not in a raceway unless permanently separated from the conductors of the other system by a continuous and firmly fixed nonconductor, such as porcelain tubes or flexible tubing, additional to the insulation on the wire.

2. In Raceways and Boxes. Conductors of Class 2 remote-control and signal circuits shall not be placed in any raceway, compartment, outlet box or similar fitting with conductors for either light and power circuits or Class 1 signal and control circuits, unless the conductors of the different systems are separated by a partition; provided that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where power supply conductors are introduced solely for supplying power to the remote-control or signal equipment to which the other conductors in the enclosure are connected.

3. In Shafts. Conductors may be run in the same shaft with conductors for light and power if the conductors of the two systems are separated at least 2 inches, or if the conductors of either system are encased in noncombustible tubing. In hoistways, conductors shall be installed in rigid conduit or electrical metallic tubing except as provided for in paragraph A of Order 13–6206.

B. *Vertical Runs.* Conductors bunched together in a vertical run in a shaft shall have fire-resistant covering capable of preventing the carrying of fire from floor to floor, except where conductors are encased in noncombustible tubing or are located in a fireproof shaft having fire stops at each floor.

The kind of insulation for the conductors shall be suitable for the particular application but is not specified in further detail as reliance is placed on current limitation to stop dangerous currents. Where 3 or more conductors are used, it is recommended that such conductors be grouped under a common braid or covering.

Order 13–7293. Circuits Extending Beyond One Building.

Class 2 remote-control and signal circuits which extend beyond one building and are so run as to be subject to accidental contact with light or power conductors operating at a potential exceeding 300 volts, shall also meet the requirements of Orders 13–8011, 13–8021, and 13–8022 of Section 13–800 of this code.

Order 13–7294. Fire Alarm Wiring.

The energy for operation of fire alarm systems shall be taken from sources suited to the design of the system. Primary batteries shall not be used.

A 3-wire 110–220 volt service will be accepted for supervised systems provided the operating current is secured from one ungrounded conductor and the neutral or grounded conductor and the current for operating trouble signal or signals is secured from the other ungrounded conductor and the neutral or grounded conductor.

Electrical wiring in connection with fire alarm systems shall be installed in rigid metal conduit, flexible metal conduit, electrical metallic tubing or surface metal raceway. Armored cable (metal) may be used where it can be fished in hollow spaces of walls or partitions in apartments or rooming houses not over three stories in height. Where the wiring is subject to excessive moisture or severe mechanical injury, rigid metal conduit shall be used. The smallest size conductor to be used in any fire alarm system in a building over three stories in height shall be No. 14 AWG or No. 16 AWG for buildings not over three stories in height. The wires shall be provided with insulation suitable for use on circuits not exceeding 600 volts. Fire alarm systems shall be connected to the line side of the

main service switch or to the emergency bus, where available, through an approved fire alarm cut-out or equivalent.

See Order 5124 of the Wisconsin State Building Code for general requirements covering fire alarm systems.

SECTION 13-730. OUTSIDE WIRING

Order 13-7301. Scope.

The requirements of this section shall apply to electrical equipment or wiring located on private or public premises, attached to the outside of or run between buildings or structures, but shall not apply to wiring for signs and other extensions of interior wiring, nor to equipment or wiring of an electric or communication utility used in the exercise of its function as a utility, except as otherwise provided in this code.

Note: For detailed orders governing the construction of facilities by a utility in the exercise of its function as a utility see Volume 1 of the Wisconsin State Electrical Code.

Order 13-7302. Application of Other Sections.

Equipment and wiring for service conductors shall comply with Section 13-230. Equipment and wiring located in hazardous locations shall comply with Section 13-500. Equipment and wiring for signs and outline lighting shall comply with Section 13-600. Equipment and wiring for remote control, low-energy power and signal circuits shall comply with Section 13-725 and equipment and wiring for communication circuits shall comply with Section 13-800.

Note: All outside lines overhead or underground operating at more than 750 volts shall be constructed in accordance with the requirements of Volume 1 of the code.

For detailed orders covering line work, reference is made to Part 2 of the Wisconsin State Electrical Code.

For signs and outline lighting, see Section 13-600.

For signal and control wiring, see Section 13-725.

GENERAL

Order 13-7311. Wiring Method.

Outside wiring may be installed as open conductors on insulating supports, as multiple-conductor cable approved for the purpose, in rigid metal conduit, in busways as provided in Orders 13-2331 and 13-3646, or in electrical metallic tubing; except that for circuits of more than 600 volts run on the exterior building walls, conductors may be installed in electrical metallic tubing only for sign and outline lighting as provided in Section 13-600. Except as provided in Order 13-2387, other conductors of more than 600 volts shall be installed in rigid metal conduit or cable approved for the purpose.

Note: For outside wiring of more than 750 volts the requirements of Part 2 of Volume 1 should be used.

Order 13-7312. Common Neutral.

For the supply of lighting equipment installed on a single pole or structure, the branch circuits shall comply with the requirements of

Section 13-210 for multi-wire branch circuits. A common neutral may be employed for the branch circuits, provided not more than 8 ungrounded conductors are used. Such a common neutral shall have a carrying capacity not less than twice the carrying capacity of one of the ungrounded conductors.

Order 13-7313. Conductor Insulation.

Open conductors supported on insulators shall be of the rubber-covered type, thermoplastic type or weatherproof (Type WP), where within 10 feet of any building or structure. Conductors in cables or raceways shall be of the rubber-covered type or thermoplastic type, and in wet locations shall comply with paragraph B of Order 13-3102. Conductors for festoon lighting shall be of the rubber-covered or thermoplastic type.

Order 13-7314. Size of Conductors.

The size of conductors shall conform to the following:

A. *Carrying Capacity.* Conductors shall conform to the allowable current-carrying capacities of Tables 1 and 2 of Chapter 10.

B. *Overhead Spans.* Overhead conductors shall not be smaller than No. 10 for spans up to 50 feet in length, and not smaller than No. 8 for longer spans.

C. *Festoon Lighting.* Overhead conductors for festoon lighting shall not be smaller than No. 12 unless supported by messenger wires.

D. *Over 600 Volts.* Overhead conductors of over 600 volts shall not be smaller than No. 6 unless in cable. Conductors in cable shall not be smaller than No. 8. Conductors operating at more than 750 volts shall comply with the requirements of Part 2 of the Code.

OPEN CONDUCTORS

Order 13-7321. Supports.

Open conductors shall be supported as follows:

A. *Open Conductors.* Open conductors shall be supported on glass or porcelain knobs, racks, brackets, or strain insulators, approved for the purpose.

B. *Festoons.* In spans exceeding 40 feet the conductors shall be supported by a messenger wire supported by approved strain insulators. Conductors or messenger wires shall not be attached to any fire escape, downspout, or plumbing equipment.

C. *Mechanical Protection.* Open conductors shall not be within 8 feet from the ground, shall not be readily accessible and shall not be subject to mechanical disturbance. Conductors within 8 feet from the ground, when readily accessible, or when subjected to mechanical disturbance, shall be protected by conduit, electrical metallic tubing, or equivalent protection.

D. *Over 750 Volts.* Supports carrying conductors operating at over 750 volts shall meet the requirements of Part 2, Volume 1 of this code.

Order 13-7322. Spacings.

Conductors shall conform to the following spacings:

A. *Open Conductors Not Exposed to Weather.* Open conductors not exposed to the weather shall be supported at intervals not exceeding 4½ feet, and shall be separated not less than 2½ inches from each other and 1 inch from the surface wired over.

B. *Open Conductors Exposed to the Weather.* Except in open spans, conductors exposed to the weather shall be supported at intervals not exceeding 9 feet, separating the conductors at least 6 inches from each other and at least 2 inches from the surface wired over; provided that supports may be placed at intervals not exceeding 15 feet if conductors are separated at least 12 inches from each other. For 300 volts or less, conductors may have a separation of not less than 3 inches if supports are placed at intervals not exceeding 4½ feet and conductors are not less than 2 inches from the surface wired over. In open spans conductors shall be separated at least 12 inches from each other.

C. *Over 600 Volts.* Except in open spans, open conductors of circuits of over 600 volts shall be separated not less than 8 inches from each other and not less than 2 inches from the surface wired over for voltages of 2500 volts or less and 3 inches for voltages exceeding 2500 volts but not exceeding 8700 volts. In open spans, conductors shall meet the requirements of Part 2, Volume 1 of this code.

D. *Separation from Other Conductors.* Open conductors shall be separated from open conductors of other circuits or systems by not less than 4 inches.

E. *Line Conductors.* Line conductors shall have a separation of not less than 1 foot if operating at a voltage of 750 volts or less. If operating at more than 750 volts the requirements of Part 2 shall be followed. If conductors of less than 750 volts are placed on racks on poles the separation shall be 4 inches for spans up to 150 feet, 6 inches for spans up to 200 feet, 8 inches for spans to 250 feet, and 12 inches for spans up to 300 feet.

Power conductors should be placed above communication conductors. For power conductors operating at less than 300 volts a climbing space of 24 inches shall be provided. If operating between 300 volts and 8,700 volts, 30 inches shall be provided. For higher voltage, see Part 2 of the Code. The climbing space for communication conductors shall be the same as required by power conductors above them.

Order 13-7323. Clearance from Ground.

Conductors shall have the following clearances from ground:

	0-150 Volts Feet	150-300 Volts Feet	300-600 Volts Feet	Over 600 Volts Feet
Over Footwalks and Spaces Accessible to Pedestrians only	10	12	15	*
Over Driveways to Residence Garages	12	12	12	*
Service Attached to Building above Ground	10	12	15	*
Over Farm Driveways	15	15	15	*
Over Parking Lots, Drive-ins, and Commercial Areas	12	12	*	*
Over Streets or Alleys in Urban Districts	18	18	18	*
Over Areas Used for Agricultural Purposes	15	15	15	*
Along Roads in Urban Districts	18	18	18	*
Along Roads in Rural Districts	15	15	15	*

*See Part 2 Volume 1 of this Code.

Order 13-7324. Clearance from Buildings.

Conductors shall have a clearance from buildings as follows:

These requirements apply specifically to open conductors, but where other approved wiring methods as provided in Order 13-7311 are employed it is necessary to obtain clearance spacings, etc., as called for by paragraphs A and/or B of this order or by attaching the raceways, cables, or messenger-supported cables in an approved manner.

A. *Over Roofs.* Open conductors (600 volts or less) shall not be less than 8 feet from the highest point of roofs but service drops operating at 300 volts or less may be not less than 3 feet from the highest point of roofs that cannot be readily walked upon. Conductors attached to roof structures shall be substantially supported. Wherever practicable, conductors crossing over buildings shall be supported on structures which are independent of the building. For voltages over 600 volts see Part 2 Volume 1 of this code.

B. *Horizontal Clearances.* Open conductors shall be not less than 36 inches from windows, doors, porches, fire escapes, or similar locations and shall conform to the following:

1. Zone for Fire Ladders. If buildings exceed 3 stories, or 50 feet in height, overhead lines shall be arranged where practicable so that a clear space (or zone) at least 6 feet wide will be left either adjacent to the buildings or beginning not over 8 feet from them, to facilitate the raising of ladders when necessary for fire fighting.

2. Less Than 8700 Volts. Open conductors of less than 8700 volts between conductors shall be at least 3 feet horizontally from buildings unless 8 feet higher than the roof.

3. Exceeding 8700 Volts. See Part 2 Volume 1 of this code.

4. Service Drops. Service drops or final spans of feeders to buildings which they serve or from which they are fed must necessarily approach the building more closely than indicated, but they shall be kept away from windows, doors, porches, fire escapes or similar locations and shall be run to the building in such a way as to avoid any hazard.

Order 13-7325. Protection on Buildings or Structures.

Where open conductors are subject to mechanical disturbance, or are readily accessible, they shall be protected by rigid metal conduit, electrical metallic tubing, shall be of multiple conductor cable approved for the purpose, or shall have equivalent protection.

Order 13–7326. Protection on Poles.

Conductors on a pole shall be protected from mechanical injury to a point at least 8 feet from the ground. Such protection shall conform to Order 13–7325.

Order 13–7327. Entering Buildings—Drip Loops.

Open conductors where they enter or leave a building shall pass upward and inward through slanting, non-combustible, non-absorptive insulating tubes. Drip loops shall be formed on the conductors outside the building.

MULTIPLE-CONDUCTOR CABLES

Order 13–7331. Multiple-Conductor Cables.

Multiple-conductor cables of Type SD shall have insulating supports at intervals not exceeding 15 feet and maintaining a distance of not less than 2 inches from the surface wired over; and shall be protected where within 8 feet from the ground or where subject to mechanical injury. Multiple-conductor cables of Type SE or ASE mounted in contact with the building shall be supported at intervals not exceeding 4½ feet.

RACEWAYS

Order 13–7341. Raceways.

Conduit and electrical metallic tubing on exterior of buildings shall be made rain-tight and suitably drained.

UNDERGROUND CONDUCTORS

Order 13–7351. Mechanical Protection.

Underground conductors shall be protected against mechanical injury by being installed in duct, in the form of a cable approved for the purpose or by other approved means.

Order 13–7352. Draining.

Underground conduits or ducts, when not located below the frost line, shall be arranged to drain.

Order 13–7353. Protection Where Entering Building.

Where undergroud conductors enter a building, they shall have mechanical protection in the form of rigid or flexible conduit, electrical metallic tubing, auxiliary gutters, or cables approved for the purpose, or other approved means.

Order 13–7354. Protection on Poles.

Underground conductors carried up a pole shall conform to Order 13–7326.

FIXTURES

Order 13–7361. Lampholders.

Lampholders shall be of molded composition, or other approved material of the weatherproof type, and if they are attached as pendants shall have the connections to the circuit wires staggered. If lampholders have terminals of a type which puncture the insulation and make contact with the conductors, they shall be attached only to conductors of the stranded type.

Order 13–7362. Location of Lamps.

For outdoor lighting, lamps shall be located below all live conductors, transformers, or other electrical equipment, unless clearances or other safeguards are provided for relamping operations, or unless the installation is controlled by a disconnecting means which can be locked in the open position.

Order 13–7363. Overcurrent Protection.

Conductors supplying outdoor lighting fixtures and utilization equipment shall be protected in the same manner as conductors supplying interior lamps and equipment. See Table 2, Chapter 10.

Note: If No. 14 conductors are used, over-current protection rated at not more than 15 amperes shall be provided. For No. 12 conductors this may be increased to 20 amperes.

Order 13–7364. Splices and Taps.

All splices and taps shall be made mechanically and electrically secure by one of the methods described in Order 13–1118.

Chapter 8. Communication Systems

SECTION 13-800. COMMUNICATION CIRCUITS

Order 13-8001. Scope.

The provisions of this section shall apply to telephone, telegraph (except radio), district messenger, fire and burglar alarms, and similar central station systems. Circuits and apparatus coming within the scope of this section and installed in Class I hazardous locations, shall comply with Order 13-5024 of Section 13-500.

Such protective measures as are essential to safeguard these systems under the various conditions to which they are subjected are outlined in these rules.

PROTECTION

Order 13-8011. Protective Devices.

A protector approved for the purpose shall be provided on each circuit, aerial or underground, so located within the block containing the building served as to be liable to accidental contact with light or power conductors operating at a potential exceeding 300 volts, and on each circuit run partly or entirely in aerial wire or cable not confined within a block.

The word "block" as used in this section shall be construed to mean a square or portion of a city, town, or village enclosed by streets and including the alleys so enclosed but not any street.

A. *Location.* The protector shall be located in or on the building as near as practicable to the point where the conductors enter. In the case of an underground entrance the protector may be located at the junction of the underground and the aerial wires.

B. *Hazardous Locations.* The protector shall not be located in any hazardous location as defined in Section 13-500, nor in the vicinity of easily ignitible material.

C. *Protector Requirements.* The protector shall be mounted on a non-combustible, non-absorptive insulating base and shall consist of an arrester between each line conductor and the ground, and a fuse in each line conductor, the fuses protecting the arrester except as specified in paragraph D. The protector terminals shall be plainly marked to indicate line, instrument, and ground.

D. *Metal Sheathed Cable.* Fuses protecting the arrester may be omitted on circuits entering a building through metal sheathed cable, provided the metal sheath of the cable is grounded and the conductors in the cable are No. 24 or smaller.

Order 13-8012. Installation of Conductors.

Conductors from the protector to the equipment or, where no protector is required, conductors attached to the outside of, or inside, the building shall comply with the following:

A. *Separation From Other Conductors.* Conductors shall be separated from conductors of electric light and power circuits as follows:

1. Open Conductors. Conductors shall be separated at least 2 inches from any light or power conductors not in metallic raceways or metal sheathed cable unless permanently separated from the conductors of the other system by a continuous and firmly fixed non-conductor, additional to the insulation on the wire, such as porcelain tubes or flexible tubing.

2. In Raceways and Boxes. Communication conductors shall not be placed in any raceway, compartment, outlet box, junction box or similar fitting with conductors for light and power circuits or Class I signal and control circuits unless the conductors of the different systems are separated by a partition; provided, that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where such conductors are introduced solely for power supply to communication equipment or for connection to remote-control equipment.

3. In Shafts. Conductors may be run in the same shaft with conductors for light and power if the conductors of the two systems are separated at least 2 inches, or if the conductors of either system are encased in non-combustible tubing.

B. *Vertical Runs.* Conductors bunched together in a vertical run in a shaft shall have a fire-resistant covering capable of preventing the carrying of fire from floor to floor, except where conductors are encased in non-combustible tubing or are located in a fireproof shaft having fire stops at each floor.

The conductors referred to in this order would ordinarily be insulated but the kind of insulation is not specified as reliance is placed on the protective device to stop all dangerous voltages and currents.

C. *Neatly Arranged.* Conductors shall be neatly arranged and shall be secured in place in a workmanlike manner.

OUTSIDE CONDUCTORS

Order 13-8021. Overhead Conductors.

Overhead conductors entering buildings shall comply with the following:

A. *On Poles.* Where the communication conductors and light or power conductors are supported by the same pole, the following conditions shall be met:

1. Relative Location. The conductors should preferably be located below the light or power conductors.

2. Attachment to Cross Arms. Conductors shall not be attached to a crossarm which carries light or power conductors.

3. Climbing Space. The climbing space through signal conductors shall comply with the requirements of Part 2 Volume 1 and Order 13-7322.

B. *On Roofs.* Conductors passing over buildings shall be kept at least 8 feet above any roof which may be readily walked upon, except small auxiliary buildings such as garages and the like.

C. *Circuits Requiring Protectors.* Circuits which require protectors (see Order 13–8011) shall comply with the following:

1. Insulation, Single or Paired Conductors. Each conductor, from the last outdoor support to the protector, shall have 1/32-inch rubber insulation, except that when such conductors are entirely within a block the insulation on the conductor may be less than 1/32-inch, but not less than 1/40-inch in thickness. In addition, the conductor, either individually or over the pair, shall be covered with a substantial fibrous covering or equivalent protection. Conductors approved for the purpose having rubber insulation of a thickness less than specified above, or having other kinds of insulation may be used.

2. Insulation, Cables. Conductors within a cable of the metal-sheathed type, or within a cable having a rubber sheath of at least 1/32-inch thickness and covered with a substantial fibrous covering, may have paper or other suitable insulation. If the metal or rubber sheath is omitted, each conductor shall be insulated as required in subparagraph C–1 of this order, and the bunched conductors shall be covered with a substantial fibrous covering or equivalent covering.

3. On Buildings. Open conductors shall be separated at least 4 inches from light or power conductors not in conduit or cable, unless permanently separated from conductors of the other system by a continuous and firmly fixed non-conductor additional to the insulation on the wires, such as porcelain tubes or flexible tubing. Open conductors exposed to accidental contact with light or power conductors operating at over 300 volts, and attached to buildings, shall be separated from woodwork by being supported on glass, porcelain or other insulating material approved for the purpose.

4. Entering Buildings. Except when a protector is installed on the outside of the building, or the entering conductors are in a cable or pass through masonry, the conductors shall enter the building either through non-combustible, non-absorptive insulating bushings, or through a metal raceway. Raceways or bushings shall slope upward from the outside or where this cannot be done, drip loops shall be formed in the conductors immediately before they enter the building. Raceways shall be equipped with an approved service head. More than one conductor may enter through a single raceway or bushing. Conduits or other metallic raceways located ahead of the protector shall be grounded.

Order 13–8022. Lightning Conductors.

When practicable, a separation of at least six feet shall be maintained between open conductors of communication systems on buildings and lightning conductors.

UNDERGROUND CIRCUITS

Order 13–8031. Underground Circuits.

Underground conductors of signal and control circuits entering buildings shall comply with the following:

A. *Not With Electric Light or Power Conductors.* Underground conductors shall not be placed in a duct, handhole, or manhole containing electric light or power conductors, except in a section separated from such conductors by means of brick, concrete, or tile partitions.

B. *Underground Block Distribution.* Where the entire street circuit is run underground and the circuit within the block is so placed as to be free from liability of accidental contact with electric light or power circuits of over 300 volts, the insulation requirements of subparagraphs C–1 and C–4 of Order 13–8021 shall not apply, the conductors need not be placed on insulating supports and no bushings shall be required where the conductors enter the building.

GROUNDING

Order 13–8041. Grounding.

Equipment shall be grounded as follows:

A. *Cable Sheath.* The metal sheath of aerial cables entering buildings and which are liable to contact with electric light or power conductors shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device.

B. *Protector Ground.* The protector ground shall comply with the following:

1. Insulation. The grounding conductor shall have a 1/32 inch rubber insulation and shall be covered by a substantial fibrous covering. Conductors approved for the purpose having less than 1/32 inch rubber insulation or having other kinds of insulation may be used.

2. Size. The grounding conductor shall not be smaller than No. 18 copper.

3. Run in Straight Line. The grounding conductor shall be run in as straight a line as practicable to the grounding electrode.

4. Mechanical Injury. Where necessary, the grounding conductor shall be guarded from mechanical injury.

5. Electrode. The grounding conductor shall preferably be connected to a water pipe electrode. In the absence of a water pipe, connection may be made to a continuous and extensive underground gas piping system, to an effectively grounded metallic structure, or to a ground rod or pipe driven into permanently damp earth. Steam or hot water pipes, or lightning rod conductors shall not be employed as electrodes for protectors. A driven rod or pipe used for grounding power circuits shall not be used for grounding communication circuits unless the driven rod or pipe is connected to the grounded conductor of a multi-grounded neutral power system. The requirements for separate made electrodes for power and lighting system grounds, those for communication systems, and those for a lightning rod installation shall not prohibit the bonding together of all such made electrodes. See Order 13–2586.

6. Electrode Connection. The grounding conductor shall be attached to a pipe electrode by means of a bolted clamp to which the conductor is soldered or otherwise connected in an effective manner.

If a gas pipe electrode is used, connection shall be made between the gas meter and the street main. In every case the connection to the grounding electrode shall be made as close to the earth as practicable.

SECTION 13-810. RADIO EQUIPMENT

Order 13-8101. Scope.

This section shall apply to radio and television receiving equipment and to amateur radio transmitting equipment, but shall not apply to equipment and antennas used for coupling carrier current to power line conductors, or to police or emergency radio systems.

It is recommended that the authority enforcing this code be freely consulted as to the specific methods to be followed in any case of doubt relative to installation of antenna and counterpoise conductors and that the National Electrical Safety Code, Part 5, be followed.

Such additional requirements applying to outside line conductors as are found in Part 2, Vol. 1 of the code must be observed.

Order 13-8102. Application of Other Sections.

Wiring from the source of power to and between devices connected to the interior wiring system shall comply with Chapters 1 to 6, inclusive, except as modified by Orders 13-6403, 13-6404, and 13-6405. Wiring for radio-frequency and audio-frequency equipment and loud speakers shall comply with Section 13-640.

ANTENNA SYSTEMS—GENERAL

Order 13-8111. Material.

Antenna, counter-poise and lead-in conductors shall be of hard drawn copper, bronze, aluminum alloy, copper-clad steel or other high strength, corrosion resistant material. Soft drawn or medium drawn copper may be used for lead-in conductors where the maximum span between points of support is less than 35 feet.

Order 13-8112. Supports.

Outdoor antenna and counter-poise and lead-in conductors shall be securely supported. They shall not be attached to poles or similar structures carrying electric light or power wires or trolley wires of more than 250 volts. Insulators supporting the antenna or counter-poise conductors shall have sufficient mechanical strength to safely support the conductors. Lead-in conductors shall be securely attached to the antenna.

In calculating the size of antenna supports located on buildings or where they may fall on buildings, power lines, communication or signal lines the wind pressure shall be taken as 20 lbs. per square foot on the exposed lattice area on one face. In the case of isolated antenna supports a wind pressure of 6 lbs. per square foot of lattice area on one face shall be used. A factor of safety of 2.5 shall be used. Strengths of single or restricted base supported antennas may be met by guying.

Order 13-8113. Avoidance of Contacts with Conductors of Other Systems.

Outdoor antenna, counter-poise and lead-in conductors from an antenna to a building shall not cross over electric light or power circuits and shall be kept well away from all such circuits so as to avoid the possibility of accidental contact. Where proximity to electric light and power service conductors of less than 250 volts cannot be avoided, the installation shall be such as to provide a clearance of at least two feet. It is recommended that antenna and counter-poise conductors be so installed as not to cross under electric light or power conductors.

Order 13-8114. Splices.

Splices and joints in antenna and counter-poise span shall be made with approved splicing devices or by such other means as will not appreciably weaken the conductors.

Soldering may ordinarily be expected to weaken the conductor. Therefore, when soldering is employed it should be independent of the mechanical support.

Order 13-8115. Structures.

Metal structures supporting antennas shall be permanently and effectively grounded. See Order 13-2592.

ANTENNA SYSTEMS—RECEIVING STATION

Order 13-8121. Size of Wire-Strung Antenna and Counter-poise.

A. Outdoor antenna and counter-poise conductors for receiving stations shall be of a size not less than given in the following table:

Material	Minimum Size of Conductors when Maximum Open Span Length Is		
	Less than 35 feet	35 feet to 150 feet	Over 150 feet
Aluminum alloy, hard-drawn copper	19	14	12
Copper-clad steel, bronze or other high strength material	20	17	14

For very long span lengths larger conductors will be required, depending on the length of the span and the ice and wind loading.

B. *Self-Supporting Antennas.* Outdoor antennas, such as vertical rods or dipole structures, shall be of non-corrodible materials and of strength suitable to withstand ice and wind loading conditions.

C. *Loading.* A wind loading of 20 pounds per square foot on the projected area and a factor of safety of 2.5 shall be used in calculating antenna support sizes.

Order 13-8122. Size of Lead-In.

Lead-in conductors from outside antenna, and counter-poise for receiving stations, shall, for various maximum open span lengths, be of such size as to have a tensile strength at least as great as that of the conductors for antenna as specified in Order 13-8121. When the lead-in consists of two or more conductors which are twisted together or are enclosed in the same covering or are concentric, the conductor size shall, for various maximum open span lengths, be such that the tensile

strength of the combination will be at least as great as that of the conductors for antenna as specified in Order 13-8121.

Order 13-8123. Clearances.

A. *On Buildings Outside.* Lead-in conductors attached to buildings shall be so installed that they cannot swing closer than two feet to the conductors of circuits of 250 volts or less or ten feet to the conductors of circuits of more than 250 volts, except that in the case of circuits not exceeding 150 volts, if all conductors involved are supported so as to insure permanent separation, the clearance may be reduced but shall not be less than four inches. The clearance between lead-in conductors and any conductor forming a part of a lightning rod system shall be not less than six feet unless the bonding referred to in Order 13-2586 is accomplished.

B. *Antennas and Lead-Ins—Indoors.* Indoor antennas and indoor lead-ins shall not be run nearer than two inches to conductors of other wiring systems in the premises unless

(1) such other conductors are in metal raceways or cable armor, or
(2) unless permanently separated from such other conductors by a continuous and firmly fixed non-conductor such as porcelain tubes or flexible tubing.

Order 13-8124. Electric Supply Circuits Used in Lieu of Antenna.

If an electric supply circuit is used in lieu of an antenna, the device by which the radio receiving set is connected to the supply circuit shall be specially approved for the purpose.

ANTENNA SYSTEM—TRANSMITTING STATIONS

Order 13-8131. Size of Antenna.

Antenna and counter-poise conductors for transmitting station shall be of a size not less than given in the following table:

Material	Minimum Size of Conductors When Maximum Open Span Length Is	
	Less than 150 feet	Over 150 feet
Hard-drawn copper	14	10
Copper-clad steel, bronze or other high strength material	14	12

For very long span length larger conductors will be required, depending on the span length and the ice and wind loading.

Order 13-8132. Size of Lead-In Conductors.

Lead-in conductors for transmitting stations shall, for various maximum span lengths, be of a size at least as great as that of conductors for antenna as specified in Order 13-8131.

Order 13-8133. Clearance on Building.

Antenna and counter-poise conductors for transmitting stations, attached to buildings, shall be firmly mounted at least 3 inches clear of the surface of the building on non-absorptive insulating supports, such as treated pins or brackets, equipped with insulators having

not less than 3-inch creepage and air-gap distances. Lead-in conductors attached to buildings shall also conform to these requirements, except when they are enclosed in a continuous metallic shield which is permanently and effectively grounded. In this latter case the metallic shield may also be used as a conductor.

Order 13-8134. Entrance to Building.

Except where protected with a continuous metallic shield which is permanently and effectively grounded, lead-in conductors for transmitting stations shall enter buildings by one of the following methods:

A. Through a rigid, non-combustible, non-absorptive insulating tube or bushing.

B. Through an opening provided for the purpose in which the entrance conductors are firmly secured so as to provide a clearance of at least 2 inches.

C. Through a drilled window pane.

Order 13-8135. Protection Against Accidental Contact.

Lead-in conductors to radio transmitters shall be so located or installed as to make accidental contact with them difficult.

PROTECTORS

Order 13-8141. Lightning Arresters—Receiving Stations.

Each conductor of a lead-in from an outdoor antenna shall be provided with a lightning arrester approved for the purpose, except that if the lead-in conductors are enclosed in a continuous metallic shield the lightning arrester may be installed to protect the shield or may be omitted if the shield is permanently and effectively grounded. Lightning arresters shall be located outside the building, or inside the building between the point of entrance of the lead-in and the radio set or transformers, and as near as practicable to the entrance of the conductors to the building. The lightning arrester shall not be located near combustible material nor in a hazardous location.

Order 13-8142. Lightning Arresters—Transmitting Stations.

Except where protected by a continuous metallic shield which is permanently and effectively grounded, or the antenna is permanently and effectively grounded, each conductor of a lead-in for outdoor antenna shall be provided with a lightning arrester or other suitable means which will drain static charges from the antenna system.

GROUNDING CONDUCTORS—GENERAL

Order 13-8151. Material.

The grounding conductor shall, unless otherwise specified, be of copper, copper-clad steel, aluminum, bronze, or other corrosion-resistant material.

Order 13-8152. Insulation.

The grounding conductors may be uninsulated.

Order 13-8153. Supports.

The grounding conductors shall be securely fastened in place and may be directly attached to the surface wired over without the use of insulating supports.

Order 13-8154. Mechanical Protection.

The grounding conductor shall be protected where exposed to mechanical injury.

Order 13-8155. Run in Straight Line.

The grounding conductor shall be run in as straight a line as possible from the antenna mast and/or lightning arrester to the grounding electrode.

Order 13-8156. Ground Electrode.

The grounding conductor shall be connected to a grounding electrode as specified in Orders 13-2581 and 13-2583 of Section 13-250.

GROUNDING CONDUCTORS—RECEIVING STATIONS

Order 13-8161. Inside or Outside Building.

The grounding conductor may be run either inside or outside the building.

Order 13-8162. Size of Protective Ground.

The protective grounding conductor for receiving stations shall be not smaller than No. 14 copper, No. 12 aluminum or No. 17 copper clad steel or bronze, provided that where wholly inside the building it shall not be smaller than No. 18.

Order 13-8163. Common Ground.

A single grounding conductor may be used for both protective and operating purposes.

If a single conductor is so used, the ground terminal of the equipment should be connected to the ground terminal of the protective device.

GROUNDING CONDUCTORS—TRANSMITTING STATIONS

Order 13-8171. Size of Protective Ground.

The protective ground conductor for transmitting stations shall be as large as the lead-in, but not smaller than No. 14 copper, bronze, or copper-clad steel.

Order 13-8172. Size of Operating Grounding Conductor.

The operating grounding conductor for transmitting stations shall be not less than No. 14 copper or its equivalent.

INTERIOR INSTALLATION—GENERAL

Order 13-8181. Radio Noise Suppressors.

Radio interference eliminators, interference capacitors or radio noise suppressors connected to power supply leads shall be of a type approved for the purpose. They shall not be exposed to mechanical injury.

TRANSMITTING STATIONS

Order 13-8191. Clearance from Other Conductors.

Except as provided in Section 13-640, all conductors inside the building shall be separated at least 4 inches from the conductor of any other light or signal circuit unless separated therefrom by conduit or some firmly fixed non-conductor such as porcelain tubes or flexible tubing.

Order 13-8192. General.

Transmitters shall comply with the following:

A. *Enclosing.* The transmitter shall be enclosed in a metal frame or grille, or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.

B. *Grounding of Controls.* All external metallic handles and controls accessible to the operating personnel shall be effectually grounded.

No circuit in excess of 150 volts should have any parts exposed to direct contact. A complete deadfront type of switchboard is preferred.

C. *Interlocks on Doors.* All access doors shall be provided with interlocks which will disconnect all voltages in excess of 350 volts when any access door is opened.

D. *Audio-Amplifiers.* Audio-amplifiers which are located outside the transmitter housing shall be suitably housed and shall be so located as to be readily accessible and adequately ventilated.

Chapter 9. Construction Specifications

This chapter of the code describes the general characteristics of fittings, materials, and devices of the types commonly employed in installations for which provisions are given in other chapters of this code. It is intended as a guide to the classification and identification of types. Such details of construction as are included in this chapter are given as descriptive information and not as a complete basis for judgment of devices or materials.

The order numbers of this chapter are derived from the chapter number, the section number to which the order refers, and a serial number. In the order number 13-92401, the prefix (13) indicates Part 3; the figure (9) indicates the chapter number; the next three figures (240), indicates that the section refers to Section 13-240, Overcurrent Protection; and the last number (1), that this is the first item in this series. Cross references are therefore omitted as the group of three digits following the figure 9 indicates the section referred to.

CARTRIDGE FUSES AND FUSEHOLDERS

Order 13-92401. Dimensions.

Cartridge fuses and fuseholders shall conform to the dimensions shown in Table 34 of Chapter 10.

Order 13-92402. Terminals.

The terminals of standard cartridge fuses and fuseholders shall be of the ferrule type for ratings of 0-60 amperes, and of the knife-blade type for ratings of 61-600 amperes.

Order 13-92403. Marking.

Fuses shall be plainly marked with the ampere rating and the name or trade-mark of the maker, and the voltage for which the fuse is designed shall be provided on a paper label which shall be navy blue for 250-volt fuses rated at 15 amperes or less, green for 250-volt fuses rated at more than 15 amperes, and red for 600-volt fuses.

LINK FUSES AND FUSEHOLDERS

Order 13-92405. Dimensions.

Link fuses and fuseholders shall have the following dimensions in inches:

Amperes Capacity	Minimum Separation of Nearest Metal Parts of Opposite Polarity	Minimum Break Distance
Not over 125 volts—601-1500	1½	1¼
Not over 250 volts—601-1500	2¾	2

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

Order 13-92406. Spacing.

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

Order 13-92407. Marking.

Link fuses shall be stamped with 80 per cent of the maximum current which they can carry indefinitely.

Order 13-92408. Material.

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

CONDUCTORS

Order 13-93101. General.

Insulated conductors shall conform to the following:

A. *Marking.* Wires, cables and cords of all kinds except weatherproof and paper-insulated wire shall have a continuous distinctive marking so that their maker may be readily identified. All wires, cables and cords shall also be plainly tagged or marked as follows:

1. The maximum working voltage for which the wire was tested or approved. This may be omitted for slow-burning, slow-burning weatherproof, weatherproof and asbestos-covered switchboard wires.
2. Name of the manufacturing company, and if desired, trade name of the wire.
3. Month and year when manufactured. This may be omitted for slow-burning, slow-burning weatherproof, and weatherproof wires.
4. The proper type letter for the particular style of wire or cable as given in the following sections.

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

C. *Classification.* In addition to the type letters specified in the table in paragraph E of this order, the following letters shall apply:

1. A type letter or letters used alone indicates a single insulated conductor.
2. D. The Letter "D" used as a suffix indicates a twin wire with two insulated conductors laid parallel under an outer fibrous covering.
3. M. The letter "M" used as a suffix indicates an assembly of two or more insulated conductors twisted together under an outer fibrous covering.

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

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

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

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

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

D. *Identified Conductors.* Single insulated conductors of No. 6 or smaller, intended for use as identified conductors of circuits, except conductors of the weatherproof type (Types WP and SBW), shall have an outer identification of a white or natural gray color. Twin and twisted-pair conductors and three-conductor cables shall have one conductor, and four-conductor cables shall have at least one conductor identified in this manner.

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

1. Single conductors, intended for use as unidentified conductors, and conductors other than the identified conductor in multi-conductor cables, shall be finished to show a color or combination of colors other than, and contrasting with, white or natural gray. For identification requirements for conductors larger than No. 6 see sub-paragraph B of Order 13–2005.

E. *Conductor Construction.* Insulated conductors for use at 600 volts or less shall conform to the provisions of the following tables:

CONDUCTOR INSULATIONS

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Rubber-Covered Fixture Wire—Solid or Stranded	RF-64	Code Rubber	18—1/64 Inch	Cotton
	RF-32	Code Rubber	18–16—2/64 Inch	Cotton
Rubber-Covered Fixture Wire—Flexible Stranding	FF-64	Code Rubber	18—1/64 Inch	Cotton or Rayon
	FF-32	Code Rubber	18–16—2/64 Inch	Cotton or Rayon
Latex Rubber Fixture Wire—Solid or Stranded	RUF	90% Unmilled Grainles Rubber	18–16—18 Mils	Moisture-resistant, flame-retardant, non-metallic covering
Flexible Stranding	RUFF	90% Unmilled Grainless Rubber	18–16—18 Mils	Moisture-resistant, flame-retardant, non-metallic covering
Thermoplastic-Covered Fixture Wire—Solid or Stranded	TF	Thermoplastic	18–16—2/64 Inch	None
Thermoplastic-Covered Fixture Wire—Flexible Stranding	TFF	Thermoplastic	18–16—2/64 Inch	None
Cotton-Covered, Heat-Resistant, Fixture Wire	CF	Impregnated Cotton	18–14—2/64 Inch	None
Asbestos-Covered, Heat-Resistant, Fixture Wire	AF	Impregnated Asbestos	18–14—2/64 Inch	None
Code	R	Code Rubber	14–12—2/64 Inch 10—3/64 Inch 8–2—4/64 Inch 1–4/0—5/64 Inch 213–500—6/64 Inch 501–1000—7/64 Inch 1001–2000—8/64 Inch	Moisture-resistant, flame-retardant, non-metallic covering

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Heat-Resistant	RH	Heat-Resistant Rubber	14–12 2/64 Inch 10 3/64 Inch 8–2 4/64 Inch 1–4/0 5/64 Inch 213–500 6/64 Inch 501–1000 7/64 Inch 1001–2000 8/64 Inch	Moisture-resistant, flame-retardant, non-metallic covering
Moisture-Resistant	RW	Moisture-Resistant Rubber	14–10 3/64 Inch 8–2 4/64 Inch 1–4/0 5/64 Inch 213–500 6/64 Inch 501–1000 7/64 Inch 1001–2000 8/64 Inch	Moisture-resistant, flame-retardant, non-metallic covering
Latex Rubber	RU	90% Unmilled, Grainless Rubber	14–10 18 Mils 8–2 25 Mils	Moisture-resistant, flame-retardant, non-metallic covering
	RUW	90% Unmilled, Grainless Rubber	14–10 18 Mils 8–2 25 Mils	Moisture-resistant, flame-retardant, non-metallic covering
Thermoplastic	T	Flame-Retardant, Thermoplastic Compound	14–10 2/64 Inch 8 3/64 Inch 6–2 4/64 Inch 1–4/0 5/64 Inch 213–500 6/64 Inch 501–1000 7/64 Inch 1001–2000 8/64 Inch	None
Moisture-Resistant Thermoplastic	TW	Flame-Retardant, Moisture-Resistant Thermoplastic	14–10 2/64 Inch 8 3/64 Inch 6–2 4/64 Inch 1–4/0 5/64 Inch 213–500 6/64 Inch 501–1000 7/64 Inch 1001–2000 8/64 Inch	None

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Thermoplastic and Asbestos	TA	Thermoplastic and Asbestos	Th'pl'. Asb. 14–8 20 Mils 20 Mils 6–2 30 Mils 25 Mils 1–4/0 40 Mils 30 Mils	Flame-retardant, cotton braid
Varnished Cambric	V	Varnished Cambric	14–8 3/64 Inch 6–2 4/64 Inch 1–4/0 5/64 Inch 213–500 6/64 Inch 501–1000 7/64 Inch 1001–2000 8/64 Inch	Non-metallic covering or lead sheath.
Asbestos and Varnished Cambric	AVA and AVL	Impregnated Asbestos and Varnished Cambric	(Dimensions in Mils) VC / AVA Asb. / AVL Asb. 14–8 (solid only) 30 / 20 / 25	AVA-asbestos braid
			1st Asb. / VC / AVA 2nd Asb. / AVL 2nd Asb. 14–8 10 / 30 / 15 / 25 6–2 15 / 30 / 20 / 25 1–4/0 20 / 30 / 30 / 30 213–500 25 / 40 / 40 / 40 501–1000 30 / 40 / 40 / 40 1001–2000 30 / 50 / 50 / 50	AVL-asbestos braid and lead sheath
Asbestos and Varnished Cambric	AVB	Impregnated Asbestos and Varnished Cambric	VC / Asb. 18–8 30 / 30 6–2 40 / 30 1–4/0 40 / 40	Flame-retardant, cotton braid (switchboard wiring)
			Asb. / VC / 2nd Asb. 14–8 10 / 30 / 15 6–2 15 / 30 / 20 1–4/0 20 / 30 / 30 213–500 25 / 40 / 40 501–1000 30 / 40 / 40 1001–2000 30 / 50 / 50	Flame-retardant, cotton braid
Asbestos	A	Asbestos	14 30 Mils 12–8 40 Mils	Without asbestos braid

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Asbestos	AA	Asbestos	14 ---- 30 Mils 12–8 ---- 30 Mils 6–2 ---- 40 Mils 1–4/0 ---- 60 Mils	With asbestos braid
Asbestos	AI	Impregnated Asbestos	14 ---- 30 Mils 12–8 ---- 40 Mils	Without asbestos braid
Asbestos	AIA	Impregnated Asbestos	Sol. / Str. 14 ---- 30 Mils / 30 Mils 12–8 ---- 30 Mils / 40 Mils 6–2 ---- 40 Mils / 60 Mils 1–4/0 ---- 60 Mils / 75 Mils 213–500 ---- 90 Mils 501–1000 ---- 105 Mils	With asbestos braid
Paper		Paper		Lead sheath
Slow Burning	SB	3 Braids Impregnated Fire Retardant, Cotton Thread	14–10 ---- 3/64 Inch 8–2 ---- 4/64 Inch 1–4/0 ---- 5/64 Inch 213–500 ---- 6/64 Inch 501–1000 ---- 7/64 Inch 1001–2000 ---- 8/64 Inch	Outer cover finished smooth and hard
Slow-Burning Weatherproof	SBW	2 Layers Impregnated Cotton Thread	14–10 ---- 3/64 Inch 8–2 ---- 4/64 Inch 1–4/0 ---- 5/64 Inch 213–500 ---- 6/64 Inch 501–1000 ---- 7/64 Inch 1001–2000 ---- 8/64 Inch	Outer fire-retardant coating
Weatherproof	WP	At least three Impregnated Cotton Braids or Equivalent		

The fibrous covering over individual rubber-covered conductors of lead-sheathed or multiple-conductor cable is not required to be flame retardant. For armored cable, see order 13-93341. For non-metallic-sheathed cable, see order 13-93361.

F. *Insulation Thickness—Over 600 Volts.* The thickness of insulation for conductors for use at over 600 volts shall conform to the following:

Thicknesses of Rubber Insulation for Rubber-Covered Wires and Cables, in 64ths of an Inch

Conductor Size Awg or MCM	Classification R10	R20	R30	R40	R50
14–8	4	5	7	9	10
6–2	5	6	8	9	10
1–4/0	6	7	8	9	10
213–500	7	8	9	10	11
501–1000	8	9	9	10	11
1001–2000	9	9	10	11	12

Thicknesses of Varnished-Cambric Insulation for Single-Conductor Cable, in 64ths of an Inch

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

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

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

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

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 For Voltages Not Exceeding 1000	2000	3000	4000	5000	2nd Wall Asbestos
	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

ARMORED CABLE, TYPES AC, ACV AND ACL

Order 13-93341. General.

Armored cable for 600 volts or less shall conform to the following:

A. *Conductors.* The conductors shall comply with the requirements for the type of conductors used. The individual conductors having a fibrous covering shall have such a covering for their entire length and, except for lead-covered cable, such covering shall be so treated as to be flame-retardant and moisture-resistant.

B. *Marking.* The cable shall carry distinctive markers throughout its entire length, both in the conductors and the armor, so that their makers may be readily identified.

NON-METALLIC SHEATHED CABLE

Order 13-93361. General.

Non-metallic sheathed cable shall conform to the following:

A. *Conductors.* The conductors shall comply with the requirements for the type of conductor used, except that no braid need be provided directly over the rubber covering.

B. *Number and Type of Conductors.* Cable shall be approved type, in sizes Nos. 14 to 4, inclusive, and in addition to the insulated conductors may have an approved size of uninsulated copper conductor for grounding purposes only.

C. *Marking.* The cable shall have a continuous distinctive marking so that the maker may be readily identified.

RIGID METAL CONDUIT

Order 13-93461. General.

Rigid conduit as shipped shall be in standard lengths of 10 feet including coupling, one coupling to be furnished with each length. Each length shall be reamed and threaded on each end. Steel conduit shall have an interior coating of a character and appearance, and non-ferrous conduit of corrosion-resistant material shall have suitable markings, so as to readily distinguish them from ordinary pipe commonly used for other than electrical purposes.

Conduit Sizes and Weights

Weights Apply to Steel Only

Stand. Pipe Size Inches	Nominal Diameter, Inches Inside	Outside	Threads Per Inch	Minimum Wt. Lbs. of Ten 10-foot Lengths of Finished Conduit with Couplings Attached
½	.622	.840	14	79.0
¾	.824	1.050	14	105.0
1	1.049	1.315	11½	153.0
1¼	1.380	1.660	11½	201.0
1½	1.610	1.900	11½	249.0
2	2.067	2.375	11½	334.0
2½	2.469	2.875	8	527.0
3	3.068	3.500	8	690.0
3½	3.548	4.000	8	831.0
4	4.026	4.500	8	982.0
4½	4.506	5.000	8	1150.0
5	5.047	5.563	8	1344.0
6	6.065	6.625	8	1770.0

ELECTRICAL METALLIC TUBING

Order 13-93481. General.

Electrical metallic tubing shall conform to the following:

A. *Cross Section.* The tubing, and elbows and bends for use with the tubing, shall have a circular cross-section.

B. *Finish.* Tubing shall have such a finish or treatment of outer surfaces as will provide an approved permanent means of readily distinguishing it, when installed, from rigid conduit.

C. *Connectors.* When 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.

SURFACE METAL RACEWAY

Order 13-93521. General.

Surface metal raceways shall be of such construction as will distinguish them from other raceways. Metal raceways and their elbows, couplings and similar fittings shall be so designed that the sections can be electrically and mechanically coupled together, while protecting the wires from abrasion. Holes for screws or bolts inside the raceway shall be so designed that when screws or bolts are in place their heads will be flush with the metal surface.

CELLULAR METAL FLOOR RACEWAYS

Order 13-93561. 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.

BOXES AND FITTINGS

Order 13-93701. Outlet, Switch and Junction Boxes and Fittings.

Outlet, switch and junction boxes and fittings, if of metal, shall conform to the following:

A. *Corrosion-Resistant.* Boxes and fittings, if of metal, unless of corrosion-resistant metal shall be well-galvanized, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

See Order 13-3003 for limitation in the use of boxes and fittings protected from corrosion solely by enamel.

It is recommended that the protective coating be of conductive material, such as cadmium, tin or zinc, in order to secure better electrical contact.

B. *Thickness of Metal.* For boxes and fittings not over 100 cubic inches in size, if constructed of sheet steel, the metal shall not be less

than No. 14 USS gauge (.0747 in.) in thickness, or if of cast metal shall have a wall thickness of not less than ⅛ inch, except that if of malleable iron, they shall have a wall thickness of not less than $\frac{3}{32}$ inch.

C. *Boxes Over 100 Cubic Inches.* Boxes of over 100 cubic inches in size shall be composed of metal and shall conform to the requirements for cabinets and cutout boxes, except that the covers may consist of single flat sheets secured to the box proper by screws, or bolts instead of hinges. Boxes having covers of this form are for use only for enclosing joints in conductors or to facilitate the drawing in of wires and cables. They are not intended to enclose switches, cutouts or other control devices.

Order 13–93702. Covers.

Covers of boxes and fittings shall be of a thickness at least that specified for the walls of boxes of the same material as that used for the cover and of the size under consideration, or shall be lined with firmly attached insulating material not less than $\frac{1}{32}$ inch in thickness. Covers of porcelain or other approved insulating material may be used if of such form and thickness as to afford the requisite protection and strength.

Order 13–93703. 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. If conductors other than flexible cord may pass through a metal cover, there shall be provided a separate hole for each wire, said hole being equipped with a bushing of suitable insulating material.

Order 13–93704. Non-Metallic Boxes.

Provisions for supports, or other mounting means, for non-metallic boxes, shall be outside of the box, or the box shall be so constructed as to prevent contact between the conductors in the box and the supporting screws.

CABINETS AND CUTOUT BOXES

Order 13–93731. Material.

Cabinets and cutout boxes shall conform to the following:

A. *Metal Cabinets and Boxes.* Metal cabinets and cutout boxes shall be well galvanized, plated with cadmium or other approved metallic finish, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

It is recommended that the protective coating be of conductive material, such as cadmium, tin or zinc, in order to secure better electrical contact.

B. *Strength.* The design and construction of cabinets and cutout boxes shall be such as to secure ample strength and rigidity. If constructed of sheet steel, the metal shall be of not less than No. 16 USS gauge (0.598 inch) in thickness.

C. *Composition Cabinets.* Composition cabinets shall be submitted for approval prior to installation.

Order 13–93732. Spacing.

The spacing within cabinets and cutout boxes shall conform to the following:

A. *General.* The spacing within cabinets and cutout boxes shall be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of devices and apparatus mounted within them as follows:

1. Base. There shall be an air space of at least $\frac{1}{16}$ inch, except at points of support, between the base of the device and the wall of any metal cabinet or cutout box, on which the device is mounted.

2. Doors—General. There shall be an air space of at least 1 inch between any live metal part (including live metal parts of enclosed fuses) and the door, unless the door is lined with an approved insulating material or is of a thickness of metal not less than No. 12 USS gauge (.1046 inch), when the air space shall be not less than ½ inch.

3. Doors—Link Fuses. There shall be a space of at least 2 inches between open link fuses and metal-lined walls or metal, metal-lined or glass-paneled doors.

4. Live Parts. Except as noted above, there shall be an air space of at least ½ 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 if the potentials do not exceed 250 volts. This spacing shall be increased to at least one inch if the potentials exceed 250 volts.

B. *Switch Clearance.* Cabinets and cutout boxes shall be deep enough to allow the closing of the doors when 30-ampere branch-circuit panelboard switches are in any position, or when combination cutout switches are in any position, or when other single-throw switches are opened as far as their construction will permit.

C. *Wiring Space—When Required.* Cabinets and cutout boxes which contain devices or apparatus connected within the cabinet or box to more than 8 conductors, including those of branch circuits, meter loops sub-feeder circuits, power circuits and similar circuits, but not including the supply circuit or a continuation thereof, shall have back wiring spaces or one or more side wiring spaces, side gutters or wiring compartments.

D. *Wiring Space—Enclosure.* Side wiring spaces, side gutters or side wiring compartments of cabinets and cutout boxes shall be rendered tight enclosures by means of covers, barriers or partitions extending from the bases of the devices, contained in the cabinet, to the door, frame, or sides of the cabinet; provided, however, that where the enclosure contains only those conductors which are led from the cabinet at points directly opposite their terminal connections to devices within the cabinet, such covers, barriers or partitions may be omitted. Partially enclosed back wiring spaces shall be provided with covers to complete enclosure. Wiring spaces that are required by

paragraph (C) of this order and which are exposed when doors are open, shall be provided with covers to complete the enclosure.

SWITCHES

Order 13–93801. Marking.

Switches shall be marked with the current and voltage and, if horsepower rated, the maximum rating for which they are designed.

Order 13–93802. 600-Volt Knife Switches.

Auxiliary contacts of a renewable or quick-break type or the equivalent, shall be provided on all 600-volt knife switches designed for use in breaking currents over 200 amperes.

It is recommended that such auxiliary contacts be provided on all direct-current switches rated at over 250 volts.

Order 13–93803. Multiple Fuses.

Switches rated above 600 amperes, and therefore exceeding the rating of standard cartridge enclosed fuses, may be arranged for fuses in multiple provided as few fuses as possible are used and the fuses are of the same type and rating and are so mounted as to eliminate a potential difference between the terminals of the fuses.

SWITCHBOARDS AND PANELBOARDS

Order 13–93841. Panels.

The panels of switchboards shall be made of moisture-resistant, non-combustible material.

Order 13–93842. Bus-bars.

Bus-bars, if rigidly mounted, may be of bare metal.

Order 13–93843. Protection of Instrument Circuits.

Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils, except where the operation of the overcurrent device might introduce a hazard in the operation of devices, shall be supplied by a circuit that is protected by standard overcurrent devices of a rating not greater than 15 amperes, except that for ratings of 2 amperes or less special types of enclosed fuses may be used.

Order 13–93844. Component Parts.

Switches, fuses, and fuseholders used on panelboards shall conform to the requirements of Sections 13–240 and 13–380 so far as they apply.

Order 13–93845. Knife Switches.

Branch-circuit switches shall be so arranged that the blades, if exposed during operation, will be dead when the switches are open.

Order 13–93846. Color-Coding.

If switchboards or panelboards are provided with color markings to indicate the main bus-bars to which branch circuit bus-bars are connected, the colors shall conform to the color coding of Order 13–2112.

Order 13–93847. Spacings.

Except at switches and circuit-breakers, at least the following distance between bare metal parts, bus-bars, etc., shall be maintained.

	Opposite Polarity When Mounted on the Same Surface	Opposite Polarity When Held Free in Air	*Live Parts to Ground
Not over 125 volts	¾ inch	½ inch	½ inch
Not over 250 volts	1¼ inch	¾ inch	½ inch
Not over 600 volts	2 inches	1 inch	1 inch

*For spacing between live parts and doors of cabinets, see sub-paragraph A of order 13–93732.

It should be noted that the above distances are the minimum allowable, and it is recommended that greater distances be adopted wherever the conditions will permit.

At switches, enclosed fuses, etc., parts of the same polarity may be placed as close together as convenience in handling will allow, unless close proximity causes excessive heating.

FLEXIBLE CORDS

Order 13–94001. Labels.

Flexible cords shall be examined and tested at the factory and shall be labeled before shipment.

Order 13–94002. Grounded Conductor Identification.

One conductor of flexible cords shall have a continuous marker readily distinguishing it from the other conductor or conductors. The identification shall consist of one of the following:

A. *Colored Braid.* A braid finished to show a white or natural gray color and the braid on the other conductor or conductors finished to show a readily distinguishable solid color or colors.

B. *Tracer in Braid.* A tracer in a braid of any color contrasting with that of the braid and no tracer in the braid of the other conductor or conductors. No tracer shall be used in the braid of any conductor of a flexible cord which contains a conductor having a braid finished to show white or natural gray, except that, in the case of types C, PD and PO cords having the braids on the individual conductors finished to show white or natural gray, the identifying marker may consist of a tracer of any color in the braid of one conductor.

C. *Colored Insulation.* A white or natural gray insulation on one conductor and insulation of a readily distinguishable color or colors on the other conductor or conductors for cords having no braids on the individual conductors (except cords which have insulation on the individual conductors integral with the jacket).

D. *Colored Separator.* A white or natural gray separator on one conductor and a separator of a readily distinguishable solid color on the other conductor or conductors of cords having insulation on the individual conductors integral with the jacket.

E. *Tinned Conductors.* One conductor having the individual strands tinned and the other conductor or conductors having the individual strands untinned for cords having insulation on the individual conductors integral with the jacket.

F. *Surface Marking.* A stripe, ridge or groove so located on the exterior of the cord as to identify one conductor for cords having insulation on the individual conductors integral with the jacket.

Order 13-94003. Grounding Conductor Identification.

A conductor intended to be used as a grounding conductor if provided with insulation shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. The identifying marker shall consist of one of the following:

A. *Colored Braid.* A braid finished to show a green color.

B. *Colored Insulation.* For cords having no braids on the individual conductors a green insulation on one conductor.

This shall not be construed as prohibiting the use of a conductor having a green finish as an ungrounded circuit conductor in cords having no conductor used as a grounding conductor.

Order 13-94004. Insulation—Required.

The individual conductor of all cords except those of heat-resistant cord (Types AFC, AFPO, AFPD, AFS, AFSJ, AVPO, AVPD, CFC, CFPO and CFPD) shall have a rubber or thermoplastic covering, except that in Types S, ST, SO, SJ, SJT, SJO, SU and SUO, cord one conductor intended for use as a grounding conductor may be without individual insulation. A rubber compound shall be vulcanized except for asbestos-covered tinsel cord (Types AT and ATJ) and heater cord (Types HC, HSJ and HPD).

Order 13-94005. Insulation Thickness.

The thickness of the rubber or thermoplastic covering shall be not less than $\frac{1}{64}$ inch for Types AT, ATJ, CT, CTJ, P-64, PO-64, POSJ-64, POT-64, PWP-64, SV, SVT, HC, HSJ, and HPD. The nominal insulation thickness for Types SU and SUO shall be .015 inch for Awg sizes 18 and 16 and .018 inch for Awg sizes 14, 12, and 10. For other types the nominal thickness of the rubber or thermoplastic covering shall be as given in the following table:

Size AWG	Thickness Inch
18 and 16	2/64
14 to 10	3/64
8	4/64

FIXTURES, LAMPHOLDERS, RECEPTACLES AND ROSETTES

Order 13-94100. Design and Material.

Fixtures shall be constructed of metal, wood, or other approved material and shall be so designed and assembled as to secure requisite mechanical strength and rigidity. Wireways, including the entrances thereto, shall be such that conductors may be drawn in and withdrawn without injury.

Order 13-94101. Fixtures.

Fixtures shall conform to the following:

A. *Material Other Than Metal.* In all fixtures not made entirely of metal, wireways shall be lined with metal unless approved armored or lead-covered conductors with suitable fittings are used.

B. *Mechanical Strength.* Tubing used for arms and stems where provided with cut threads shall be not less than 0.040 inch in thickness and when provided with rolled (pressed) threads shall be not less than 0.025 inch in thickness. Arms and other parts shall be fastened to prevent turning. Metal canopies supporting lampholders, shades, etc., exceeding 8 lbs., or incorporating attachment plug receptacles, shall be not less than 0.020 inch in thickness. Other canopies shall be not less than 0.016 inch when made of steel and not less than 0.020 inch when of other metals. Pull type canopy switches shall not be inserted in the rims of metal canopies which are less than 0.025 inch in thickness unless the rims are reinforced by the turning of a bead or the equivalent. Pull type canopy switches, whether mounted in the rims or elsewhere in sheet metal canopies, shall be located not more than 3½ inches from the center of the canopy. Double set screws, double canopy rings, a screw ring, or equal method shall be used where the canopy supports a pull type switch or pendent receptacle.

The above thickness requirements apply to measurements made on finished (formed) canopies.

C. *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 nonabsorptive, noncombustible material.

D. *Fixture Studs.* Fixture studs which are not parts of outlet boxes, hickeys, tripods, and crowfeet shall be made of steel, malleable iron, or other approved material.

E. *Insulating Joints.* Insulating joints shall be composed of materials especially approved for the purpose. Those which are not designed to be mounted with screws or bolts shall have a substantial exterior metal casing, insulated from both screw connections.

F. *Portables.* Portable table and floor lamps and fan motors on ceiling fixtures may be wired with approved rubber-covered conductors, provided the wiring is not located so as to be subject to undue heating from lamps.

G. *Cord Bushings.* Bushings 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.

H. *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.

I. *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 ½ inch between live parts and the mounting plane of the fixture.

LAMPHOLDERS

Order 13-94102. General.

Lampholders shall conform to the following:

A. *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 ⅛ inch, but shall prevent any current-carrying part of the lamp base from being exposed when a lamp is in the lamp-holding device.

B. *Lead Wires.* Lead wires, furnished as a part of weatherproof lampholders and intended to be exposed after installation, shall be of approved, stranded, rubber-covered conductors, not less than No. 14 gauge (No. 18 gauge for candelabra sockets), and shall be sealed in place or otherwise made raintight.

C. *Switched Lampholders.* Switched lampholders shall be of such construction that the switching mechanism interrupts the electrical connection to the center contact. The switching mechanism may also interrupt the electrical connection to the screw shell if connection to the center contact is simultaneously interrupted.

D. *Screw-Shell Lampholders.* Screw-shell lampholders shall be classed according to diameters of lamp bases, as Candelabra, Intermediate, Medium, Admedium, and Mogul base; having respectively ½ inch, 21/32 inch, 1 inch, 1 1/16 inch, and 1½ inch nominal sizes, with ratings, as specified in the following table:

		Ratings—Switched			Ratings—Unswitched		
Class	Nominal Diam.	Watts	Volts	Max. Amp. at any Voltage	Watts	Volts	Max. Amp. at any Voltage
Candelabra	½ in.	75	125	¾	75	125	1
Intermediate	21/32 in.	75	125	¾	75	250	1
Medium	1 in.	250	250	2½	660	250	6
		660(a)	250	6	660	600	
Admedium	1 1/16 in.				660	250	
Mogul	1½ in.	750	250		1500	250	
		1500	250		1500	600	

(a) This rating may be given only to lampholders having a switch mechanism which produces both a quick "make" and a quick "break" action.

Miniature lampholders and receptacles having screw-shells smaller than the candelabra size may be used for decorative lighting systems, Christmas-tree lighting outfits and similar purposes.

For exceptions for medium base key lampholders and receptacles see Section 13-720.

INCANDESCENT LAMPS

Order 13-94103. Bases.

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 1,500 watts. Above 1,500 watts special approved bases or other devices shall be used.

ROSETTES

Order 13-94104. Rosettes.

Rosettes shall conform to the following:

A. *Rating.* Rosettes shall be rated at 660 watts, 250 volts, with a maximum current rating of 6 amperes.

B. *For Exposed Wiring.* If designed for use with exposed wiring, rosettes shall be provided with bases which shall have at least two holes for supporting screws, shall be high enough to keep the wires and terminals at least ½ inch from the surface wired over, and shall have a porcelain lug under each terminal to prevent the rosette being placed over projections which would reduce the separation to less than ½ inch.

C. *For Use With Boxes or Raceways.* If designed for use with conduit boxes or wire raceways, rosette bases shall be high enough to keep wires and terminals at least ⅜ inch from the surface wired over.

D. *Fuseless.* Fused rosettes shall not be used.

E. *Non-separable.* Separable rosettes which make possible a change in polarity shall not be used.

FLUSH AND RECESSED FIXTURES

Order 13-94105. Flush and Recessed Fixtures.

Flush and recessed fixtures shall conform to the following:

A. *Temperature.* Fixtures shall be so constructed that adjacent combustible material will not be subject to temperatures in excess of 90C (194F).

B. *Enclosure.* Sheet metal enclosures shall be protected against corrosion by galvanizing, plating, or other equivalent heat-resisting coating, and shall not be less than No. 22 USS gauge (.0299 in.).

C. *Lamp Stops.* Where enclosures are of a size which permits the use of lamps which will permit the temperature limits specified in sub-paragraph A to be exceeded, lamp stops shall be provided to prevent the use of excess size lamps.

D. *Use of Solder Prohibited.* No solder shall be used in the construction of the fixture box.

E. *Lampholders.* Lampholders of the screw-shell type shall be of porcelain unless specially approved for the purpose. Cements, if used, shall be of the high-heat type.

F. *Conductor Insulation.* Recessed fixtures shall be wired with type AF or AI fixture wire.

ELECTRIC DISCHARGE LAMPS

Order 13-94106. General.

Fixtures constructed for electric discharge lighting in addition to conforming to the applicable requirements for electric discharge lighting, and the general requirements for all lighting fixtures, shall conform to the following. For signs and outline lighting, see Section 13-600.

A. *Lampholders.* Lampholders shall be classed according to the dimensions and spacings of the pins in the lamp bases, as shown in the following table:

		Pin Dimensions		
Class	Rating	Dia.	Length	Spacing
Small Bipin	75 watts	3/32 in.	9/32 in.	3/16 in.
Standard Bipin	660 watts	3/32 in.	9/32 in.	1/2 in.
Large Bipin	660 watts	1/8 in.	5/8 in.	25/32 in.
Standard Single Pin	660 watts	5/16 in.	5/16 in.	

MERCURY-VAPOR LAMPS

Order 13–94107. Enclosure of Resistors and Regulators.

Resistors or regulators for mercury-vapor lamps shall be enclosed in non-combustible cases and treated as sources of heat.

MOTORS AND CONTROLLERS

Order 13–94301. Bushings.

Soft-rubber bushings may be used to protect lead wires where they pass through the frame of a motor, but only where they will not be exposed to oils, grease, oily vapors, or other substances having a deleterious effect on rubber.

Order 13–94302. Auto-Transformer—Design.

An auto-transformer starter shall provide an off position, a running position, and at least one starting position. It shall be so designed that it cannot rest in the starting position, or in any position, which will render inoperative the overcurrent protective device in the circuit.

Order 13–94303. Rheostats.

Rheostats shall conform to the following:

A. *Internal Connections.* Motor-starting rheostats shall be so designed that the contact arm cannot be left on intermediate segments. The point or plate on which the arm rests when in the starting position shall have no electrical connection with the resistor.

B. *Under-voltage Release.* Motor-starting rheostats for direct-current motors shall be equipped with automatic devices which will interrupt the supply before the speed of the motor has fallen to less than one-third its normal value.

Order 13–94304. Identifying Code Letters.

Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with the following table:

Code Letter	Kilovolt-Amperes per Horsepower, with Locked Rotor
A	0 — 3.14
B	3.15 — 3.54
C	3.55 — 3.99
D	4.0 — 4.49
E	4.5 — 4.99
F	5.0 — 5.59
G	5.6 — 6.29
H	6.3 — 7.09
J	7.1 — 7.99
K	8.0 — 8.99
L	9.0 — 9.99
M	10.0 — 11.19
N	11.2 — 12.49
P	12.5 — 13.99
R	14.0 — 15.99
S	16.0 — 17.99
T	18.0 — 19.99
U	20.0 — 22.39
V	22.4 — and up

The above table is an adopted standard of the National Electrical Manufacturers Association.

GENERATORS

Order 13–94451. Bushings.

Soft-rubber bushings may be used to protect lead wires where they pass through the frame of generators, but only where they will not be exposed to oils, grease, oily vapors, or other substances having a deleterious effect on rubber.

TRANSFORMERS

Order 13–94501. Case or Enclosure.

Dry-type transformers shall be provided with a non-combustible moisture-resistant case or enclosure which will provide reasonable protection against the accidental insertion of foreign objects.

Order 13–94502. Leads.

The primary leads of transformers supplying Class 2 remote-control and signal circuits may be smaller than No. 14 but not smaller than No. 18, provided they are not over 12 inches long, have insulation at least equal to type RF–32 rubber-covered fixture wire, or approved equivalent.

CAPACITORS

Order 13–94601. Cases and Supports.

Capacitors shall be provided with non-combustible cases and supports.

RESISTORS AND REACTORS

Order 13–94701. Contacts.

Fixed and movable contacts shall be so designed that arcing will be kept at a minimum.

Order 13–94702. Materials.

Reactors shall be composed of non-combustible materials, and shall be mounted on non-combustible bases.

Chapter 10. Tables, Diagrams, Examples

Table 1—Allowable Current-Carrying Capacities of Insulated Conductors in Amperes

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

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

CORRECTION FACTOR FOR ROOM TEMPERATURES OVER 30 C. 86 F.

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

Table 2—Allowable Current-Carrying Capacities of Insulated Conductors in Amperes

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

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

CORRECTION FACTOR FOR ROOM TEMPERATURES OVER 30 C. 86 F.

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

See Notes, following this table.

NOTES TO TABLES 1 and 2

For explanation of Type Letters, and for recognized size of conductors for the various conductor insulations, see Orders 13–3102 and 13–93101. For installation requirements, see Order 13–3102 and the various sections of this code. For flexible cords see Tables 3 and 31.

1. *Aluminum Conductors.* For aluminum conductors, the allowable current-carrying capacities shall be taken as 84 per cent of those given in the table for the respective sizes of copper conductor with the same kind of insulation.

2. *Bare Conductors.* If bare conductors are used with insulated conductors, their allowable current-carrying capacity shall be limited to that permitted for the insulated conductor with which they are used.

3. *Application of Table.* For open wiring on insulators and for concealed knob-and-tube work, the allowable current-carrying capacities of Table 2 shall be used. For all other recognized wiring methods, the allowable current-carrying capacities of Table 1 shall be used, unless otherwise provided in this code.

4. *More Than Three Conductors in a Raceway.* Table 1 gives the allowable current-carrying capacity for not more than three conductors in a raceway or cable. If the number of conductors in a raceway or cable is from 4 to 6, the allowable current-carrying capacity of each conductor shall be reduced to 80 per cent of the values in Table 1. If the number of conductors in a raceway or cable is from 7 to 9, the allowable current-carrying capacity of each conductor shall be reduced to 70 per cent of the values in Table 1.

Exceptions to the foregoing are specified in Orders 13–3624, 13–3745, and 13–7265.

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

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

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

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

8. *Voltage Drop.* The allowable current-carrying capacities in Tables 1 and 2 are based on temperature alone and do not take voltage drop into consideration.

9. *Overcurrent Protection.* If the standard ratings and settings of overcurrent devices do not correspond with the ratings and settings allowed for conductors, the next higher standard rating and setting may be used, but not exceeding 150 per cent of the allowable carrying capacity of the conductor.

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

Table 3—Allowable Current-Carrying Capacity of Flexible Cord and Fixture Wire in Amperes†

(Based on Room Temperature of 30 C. 86 F. See Order 13–4008 and Table 31 of Chapter 10)

Size AWG	Flexible Cord						Fixture Wire	
	Rubber and Cotton Types CT, CTJ Rubber and Asbestos Types AT, ATJ	Rubber Types PO, C, PD, P, PWP, K, E, EO Armored Type CA	Rubber Types S, SO, SJ, SJO, SU, SUO, SV, POSJ Thermoplastic Types ST, SJT, SVT, POT	Types AFS, AFSJ, HC, HPD, HSJ	Types AVPO AVPD	Cotton Types CFC* CFPO* CFPD* Asbestos Types AFC* AFPO* AFPD*	Rubber Types RF–64 RF–32 FF–64 FF–32 RUF RUFF	Thermoplastic Types TF TFF Cotton Type CF* Asbestos Type AF*
27**	0.5	--	--	--	--	--	--	--
18	---	5	7	10	17	6	5	6
17	---	--	--	12	--	--	--	--
16	---	7	10	15	22	8	7	8
15	---	--	--	17	--	--	--	--
14	---	15	15	20	28	17	--	17
12	---	20	20	--	36	--	--	--
10	---	25	25	--	47	--	--	--
8	---	35	--	--	--	--	--	--
6	---	45	--	--	--	--	--	--
4	---	60	--	--	--	--	--	--
2	---	80	--	--	--	--	--	--

*These types are used almost exclusively in fixtures where they are exposed to high temperatures and ampere ratings are assigned accordingly.
**Tinsel cord.

MORE THAN THREE CONDUCTORS IN A CORD

Table 3 gives the allowable current-carrying capacities for not more than three current-carrying conductors in a cord. If the number of current-carrying conductors in a cord is from four to six the allowable current-carrying capacity of each conductor shall be reduced to 80 per cent of the values in the table.

Tables 4 to 11. Tables 4 to 11 apply to complete conduit systems, and do not apply to short sections of conduit used for the protection of exposed wiring from mechanical injury.

Table 4—Number of Conductors in Conduit or Tubing

Rubber Covered, Types RF-32, RUF, R, RH, RW, RU, and RUW
Thermoplastic, Types TF, T and TW

One to Nine Conductors

For more than nine conductors see Table 9

(See Orders 13-3013, 13-3466 and 13-3486)

Size AWG MCM	Number of Conductors in One Conduit or Tubing								
	1	2	3	4	5	6	7	8	9
18	½	½	½	½	½	½	½	¾	¾
16	½	½	½	½	½	½	¾	¾	¾
14	½	½	½	½	¾	¾	1	1	1
12	½	½	½	¾	¾	1	1	1	1¼
10	½	¾	¾	¾	1	1	1	1¼	1¼
8	½	¾	¾	1	1¼	1¼	1¼	1½	1½
6	½	1	1	1¼	1½	1½	2	2	2
4	½	1¼	*1¼	1½	1½	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1¼	1¼	2	2	2	2½	2½	2½
1	¾	1½	1½	2	2½	2½	2½	3	3
0	1	1½	2	2	2½	2½	3	3	3
00	1	2	2	2½	2½	3	3	3	3½
000	1	2	2	2½	3	3	3	3½	3½
0000	1¼	2	2½	3	3	3	3½	3½	4
250	1¼	2½	2½	3	3	3½	4	4	4½
300	1¼	2½	2½	3	3½	4	4	4½	4½
350	1¼	3	3	3½	3½	4	4½	4½	5
400	1½	3	3	3½	4	4	4½	5	5
500	1½	3	3	3½	4	4½	5	5	6
600	2	3½	3½	4	4½	5	6	6	6
700	2	3½	3½	4½	5	5	6	6	---
750	2	3½	3½	4½	5	6	6	6	---
800	2	3½	4	4½	5	6	6	---	---
900	2	4	4	5	6	6	6	---	---
1000	2	4	4	5	6	6	---	---	---
1250	2½	4½	4½	6	6	---	---	---	---
1500	3	5	5	6	---	---	---	---	---
1750	3	5	6	6	---	---	---	---	---
2000	3	6	6	---	---	---	---	---	---

*Where a service run of conduit or electrical metallic tubing does not exceed 50 feet in length and does not contain more than the equivalent of two quarter bends from end to end, two No. 4 insulated and one No. 4 bare conductors may be installed in 1-inch conduit or tubing.
See Note 4 to Tables 1 and 2.

Table 5—Number of Conductors in Conduit or Tubing

Lead-Covered Types RL and RHL—600 V.

(See Orders 13-3466 and 13-3486)

Size AWG MCM	Number of Conductors in One Conduit or Tubing											
	Single Conductor Cable				2-Conductor Cable				3-Conductor Cable			
	1	2	3	4	1	2	3	4	1	2	3	4
14	½	¾	¾	1	¾	1	1	1¼	¾	1¼	1½	1½
12	½	¾	¾	1	¾	1	1¼	1¼	1	1¼	1½	2
10	½	¾	1	1	¾	1¼	1¼	1½	1	1½	2	2
8	½	1	1¼	1½	1	1¼	1½	2	1	2	2	2½
6	¾	1¼	1½	1½	1¼	1½	2	2½	1¼	2½	3	3
4	¾	1¼	1½	1½	1¼	2	2½	2½	1½	3	3	3½
3	¾	1¼	1½	2	1½	2	2½	3	1½	3	3	3½
2	1	1¼	1½	2	1¼	2	2½	3	1½	3	3½	4
1	1	1½	2	2	1½	2½	3	3½	2	3½	4	4½
0	1	2	2	2½	2	2½	3	3½	2	4	4½	5
00	1	2	2	2½	2	3	3½	4	2½	4	4½	5
000	1¼	2	2½	2½	2	3	3½	4	2½	4½	4½	6
0000	1¼	2½	2½	3	2½	3	3½	4½	3	5	6	6
250	1¼	2½	3	3	-----	-----	-----	-----	3	6	6	-----
300	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
350	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
400	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
500	1½	3	3½	4	-----	-----	-----	-----	4	6	-----	-----
600	2	3½	4	4½	-----	-----	-----	-----	-----	-----	-----	-----
700	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
750	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
800	2	4	4½	5	-----	-----	-----	-----	-----	-----	-----	-----
900	2½	4	4½	5	-----	-----	-----	-----	-----	-----	-----	-----
1000	2½	4½	4½	6	-----	-----	-----	-----	-----	-----	-----	-----
1250	3	5	5	6	-----	-----	-----	-----	-----	-----	-----	-----
1500	3	5	6	6	-----	-----	-----	-----	-----	-----	-----	-----
1750	----	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----
2000	3½	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----

The above sizes apply to straight runs or with nominal offsets equivalent to not more than two quarter-bends.
See order 13-3470 for bends in conduit.

Table 9—Number of Conductors in Conduit or Tubing

More Than Nine Conductors

Rubber-Covered Types RF-32, RUF, R, RH, RU, RUW, RW
Thermoplastic Types TF, T, and TW

*When Specially Permitted by This Code

(See Order 13-3012)

Size AWG	Maximum Number of Conductors in Conduit or Tubing						
	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch
18	12	20	35	49	80	115	176
16	10	17	30	41	68	97	150
14	--	10	18	25	40	59	90
12	--	--	15	21	35	50	77
10	--	--	13	17	29	41	64
8	--	--	--	10	17	25	38
6	--	--	--	--	--	15	23

*More than nine conductors are permitted in a single conduit for conductors between a motor and its controller; stage pocket and border circuits, order 13-5212; sign flashers, order 13-6021D; elevator control conductors, order 13-6214; signal and control circuits, section 13-725.

Table 11—Combination of Conductors

(See Orders 13-3466 and 13-3486)

For groups or combinations of conductors not included in the Tables 4, 5 or 9, the conduit or tubing shall be of such size that the sum of the cross-sectional areas of the individual conductors will not be more than the percentage of the interior cross-sectional area of the conduit or tubing shown in the following table:

Per Cent Area of Conduit or Tubing

	Number of Conductors				
	1	2	3	4	Over 4
*Conductors (not lead covered) (for new work)	53	31	43	40	40
Lead-covered conductors	55	30	40	38	35
**For rewiring existing raceways for increased load where it is impracticable to increase the size of the raceway due to structural conditions	60	40	50	50	50

See Note to Table 13 for size of conduit or tubing for combinations of conductors not shown in Table 4.

For carrying capacity of more than three conductors in a conduit or tubing, see Tables 1 and 2, Note 4.

See Tables 12 to 19 for dimensions of conductors, conduit and tubing.

*Use actual dimensions of wire or cable unless it is smaller than dimension of RW. Use dimension of RW as minimum dimension. Limited to nine wires maximum except as permitted in Table 9.

**For rewiring, figure dimension of wire or cable actually used. More than nine wires permitted if not over 50% fill.

For exposed runs of service conduit or tubing not over 30 feet in length, the size of conduit or tubing may be determined as permitted for rewiring.

For multi-conductor cables use actual cable cross-section areas. Conductor numbers at head of columns shall be taken as numbers of cables.

Tables 12 to 17 and 19. Tables 12 to 17 and 19 give the nominal size of conductors and conduit or tubing recommended for use in computing size of conduit or tubing for various combinations of conductors. The dimensions represent average conditions only, and while variations will be found in dimensions of conductors and conduits of different manufacture, these variations will not affect the computation.

Table 12—Dimensions and Per Cent Area of Conduit and of Tubing

Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 11

Trade Size	Internal Diameter Inches	Area—Square Inches																	
			New Work											Rewiring					
			Not Lead Covered				Lead Covered							Not Lead Covered					
		Total 100%	1 Cond. 53%	2 Cond. 31%	3 Cond. 43%	4 Cond. and Over 40%	1 Cond. 55%	2 Cond. 30%	3 Cond. 40%	4 Cond. 38%	Over 4 Cond. 35%	1 Cond. 60%	2 Cond. 40%	3 Cond. and Over 50%					
½	.622	.30	.16	.09	.13	.12	.17	.09	.12	.11	.11	.18	.12	.15					
¾	.824	.53	.28	.16	.23	.21	.29	.16	.21	.20	.19	.32	.21	.27					
1	1.049	.86	.46	.27	.37	.34	.47	.26	.34	.33	.30	.52	.34	.43					
1¼	1.380	1.50	.80	.47	.65	.60	.83	.45	.60	.57	.53	.90	.60	.75					
1½	1.610	2.04	1.08	.63	.88	.82	1.12	.61	.82	.78	.71	1.22	.82	1.02					
2	2.067	3.36	1.78	1.04	1.44	1.34	1.85	1.01	1.34	1.28	1.18	2.02	1.34	1.68					
2½	2.469	4.79	2.54	1.48	2.06	1.92	2.63	1.44	1.92	1.82	1.68	2.87	1.92	2.40					
3	3.068	7.38	3.91	2.29	3.17	2.95	4.06	2.21	2.95	2.80	2.58	4.43	2.95	3.69					
3½	3.548	9.90	5.25	3.07	4.26	3.96	5.44	2.97	3.96	3.76	3.47	5.94	3.96	4.95					
4	4.026	12.72	6.74	3.94	5.47	5.09	7.00	3.82	5.09	4.83	4.45	7.63	5.09	6.36					
4½	4.506	15.95	8.45	4.94	6.86	6.38	8.77	4.78	6.38	6.06	5.57	9.57	6.38	7.98					
5	5.047	20.00	10.60	6.20	8.60	8.00	11.00	6.00	8.00	7.60	7.00	12.00	8.00	10.00					
6	6.065	28.89	15.31	8.96	12.42	11.56	15.89	8.67	11.56	10.98	10.11	17.33	11.56	14.45					

Table 13—Dimensions of Rubber-Covered and Thermoplastic-Covered Conductors

Size AWG MCM	Types RF-32, R, RH, RW		Types TF, T, TW, RU**, RUF, RUW	
	Approx. Diam. Inches	Approx. Area Sq. Ins.	Approx. Diam. Inches	Approx. Area Sq. Ins.
18	.146	.0167	.106	.0088
16	.158	.0196	.118	.0109
14	1/32 in. .171	.0230	.131	.0135
14	3/64 in. .204*	.0327*		
12	1/32 in. .188	.0278	.148	.0172
12	3/64 in. .221*	.0384*		
10	.242	.0460	.168	.0224
8	.311	.0760	.228	.0408
6	.397	.1238	.323	.0819
4	.452	.1605	.372	.1087
3	.481	.1817	.401	.1263
2	.513	.2067	.433	.1473
1	.588	.2715	.508	.2027
0	.629	.3107	.549	.2367
00	.675	.3578	.595	.2781
000	.727	.4151	.647	.3288
0000	.785	.4840	.705	.3904
250	.868	.5917	.788	.4877
300	.933	.6837	.843	.5581
350	.985	.7620	.895	.6291
400	1.032	.8365	.942	.6969
500	1.119	.9834	1.029	.8316
600	1.233	1.1940	1.143	1.0261
700	1.304	1.3355	1.214	1.1575
750	1.339	1.4082	1.249	1.2252
800	1.372	1.4784	1.282	1.2908
900	1.435	1.6173	1.345	1.4208
1000	1.494	1.7531	1.404	1.5482
1250	1.676	2.2062	1.577	1.9532
1500	1.801	2.5475	1.702	2.2748
1750	1.916	2.8895	1.817	2.5930
2000	2.021	3.2079	1.922	2.9013

*The dimensions of Type RW wire. Also, these dimensions to be used for new work in computing size of conduit or tubing for combinations of wires not shown in Table 4.
**No. 14 to No. 2.
No. 18 to No. 8, solid; No. 6 and larger, stranded.

Table 16—Dimensions of Lead-Covered Conductors

Types RL, RHL, and RUL

Size AWG-MCM	Single Conductor		Two Conductor		Three Conductor	
	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.
14	.28	.062	.28 x .47	.115	.59	.273
12	.29	.066	.31 x .54	.146	.62	.301
10	.35	.096	.35 x .59	.180	.68	.363
8	.41	.132	.41 x .71	.255	.82	.528
6	.49	.188	.49 x .86	.369	.97	.738
4	.55	.237	.54 x .96	.457	1.08	.916
2	.60	.283	.61 x 1.08	.578	1.21	1.146
1	.67	.352	.70 x 1.23	.756	1.38	1.49
0	.71	.396	.74 x 1.32	.859	1.47	1.70
00	.76	.454	.79 x 1.41	.980	1.57	1.94
000	.81	.515	.84 x 1.52	1.123	1.69	2.24
0000	.87	.593	.90 x 1.64	1.302	1.85	2.68
250	.98	.754	----------	----	2.02	3.20
300	1.04	.85	----------	----	2.15	3.62
350	1.10	.95	----------	----	2.26	4.02
400	1.14	1.02	----------	----	2.40	4.52
500	1.23	1.18	----------	----	2.59	5.28

Note—No. 14 to No. 8, solid conductors: No. 6 and larger, stranded conductors. Data for 1/32-inch insulation not yet compiled.

Table 17—Dimensions of Asbestos-Varnished-Cambric Insulated Conductors

Types AVA, AVB, and AVL

Size AWG MCM	Type AVA		Type AVB		Type AVL	
	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.
14	.245	.047	.205	.033	.320	.080
12	.265	.055	.225	.040	.340	.091
10	.285	.064	.245	.047	.360	.102
8	.310	.075	.270	.057	.390	.119
6	.395	.122	.345	.094	.430	.145
4	.445	.155	.395	.123	.480	.181
2	.505	.200	.460	.166	.570	.255
1	.585	.268	.540	.229	.620	.300
0	.625	.307	.580	.264	.660	.341
00	.670	.353	.625	.307	.705	.390
000	.720	.406	.675	.358	.755	.447
0000	.780	.478	.735	.425	.815	.521
250	.885	.616	.855	.572	.955	.715
300	.940	.692	.910	.649	1.010	.800
350	.995	.778	.965	.731	1.060	.885
400	1.040	.850	1.010	.800	1.105	.960
500	1.125	.995	1.095	.945	1.190	1.118
550	1.165	1.065	1.135	1.01	1.265	1.26
600	1.205	1.140	1.175	1.09	1.305	1.34
650	1.240	1.21	1.210	1.15	1.340	1.41
700	1.275	1.28	1.245	1.22	1.375	1.49
750	1.310	1.35	1.280	1.29	1.410	1.57
800	1.345	1.42	1.315	1.36	1.440	1.63
850	1.375	1.49	1.345	1.43	1.470	1.70
900	1.405	1.55	1.375	1.49	1.505	1.78
950	1.435	1.62	1.405	1.55	1.535	1.85
1,000	1.465	1.69	1.435	1.62	1.565	1.93

Note: No. 14 to No. 8, solid, No. 6 and larger, stranded; except AVL where all sizes are stranded.

Varnished-Cambric Insulated Conductors Type V

The insulation thickness for varnished-cambric conductors, Type V, is the same as for rubber-covered conductors, Type R, except for Nos. 14 and 12 which have 3/64-inch insulation for varnished-cambric and 2/64-inch insulation for rubber-covered conductors and for No. 8 which has 3/64-inch insulation for varnished-cambric, and 4/64-inch insulation for rubber-covered conductors. See table in Order 13–93101. Tables 4 and 5 may, therefore, be used for the number of varnished-cambric insulated conductors in a conduit or tubing.

Table 18—Properties of Copper Conductors

Size AWG	Area Cir. Mils	Concentric Lay Stranded Conductors		Bare Conductors		D. C. Resistance Ohms/M'Ft. At 25 C. 77 F.	
		No. Wires	Diam. Each Wire Inches	Diam. Inches	*Area Sq. Inches	Bare Cond.	Tin'd. Cond.
18	1624	Solid	.0403	.0403	.0013	6.510	6.77
16	2583	Solid	.0508	.0508	.0020	4.094	4.25
14	4107	Solid	.0641	.0641	.0032	2.575	2.68
12	6530	Solid	.0808	.0808	.0051	1.619	1.69
10	10380	Solid	.1019	.1019	.0081	1.018	1.06
8	16510	Solid	.1285	.1285	.0130	.641	.660
6	26250	7	.0612	.184	.027	.410	.426
4	41740	7	.0772	.232	.042	.259	.269
3	52640	7	.0867	.260	.053	.205	.213
2	66370	7	.0974	.292	.067	.162	.169
1	83690	19	.0664	.332	.087	.129	.134
0	105500	19	.0745	.373	.109	.102	.106
00	133100	19	.0837	.418	.137	.0811	.0844
000	167800	19	.0940	.470	.173	.0642	.0668
0000	211600	19	.1055	.528	.219	.0509	.0524
	250000	37	.0822	.575	.260	.0431	.0444
	300000	37	.0900	.630	.312	.0360	.0371
	350000	37	.0973	.681	.364	.0308	.0318
	400000	37	.1040	.728	.416	.0270	.0278
	500000	37	.1162	.814	.520	.0216	.0225
	600000	61	.0992	.893	.626	.0180	.0185
	700000	61	.1071	.964	.730	.0154	.0159
	750000	61	.1109	.998	.782	.0144	.0148
	800000	61	.1145	1.031	.835	.0135	.0139
	900000	61	.1215	1.093	.938	.0120	.0124
	1000000	61	.1280	1.152	1.042	.0108	.0111
	1250000	91	.1172	1.289	1.305	.00864	.00890
	1500000	91	.1284	1.412	1.566	.00719	.00740
	1750000	127	.1174	1.526	1.829	.00617	.00636
	2000000	127	.1255	1.631	2.089	.00539	.00555

*Area given is that of a circle having a diameter equal to the overall diameter of a stranded conductor.

The values given in the table are those given in Circular 31 of the National Bureau of Standards except that those shown in the last column are those given in Specification B33 of the American Society for Testing Materials.

The resistance values given in the last two columns are applicable only to direct current. When conductors larger than No. 4/0 are used with alternating current the following multiplying factors should be used to compensate for skin effect.

Table 18-a—Multiplying Factors for Converting D.C. Resistance to A.C. Resistance

Size C M	Multiplying Factor	
	25 Cycles	60 Cycles
250000	-----	1.005
300000	-----	1.006
350000	-----	1.009
400000	-----	1.011
500000	-----	1.018
600000	1.005	1.025
700000	1.006	1.034
750000	1.007	1.039
800000	1.008	1.044
900000	1.010	1.055
1000000	1.012	1.067
1250000	1.019	1.102
1500000	1.027	1.142
1750000	1.037	1.185
2000000	1.048	1.233

Table 19—Dimensions of Conduit or Tubing

Size	Internal Diameter Inches	Area Square Inches	Size	Internal Diameter Inches	Area Square Inches
½	.622	.30	3	3.068	7.38
¾	.824	.53	3½	3.548	9.90
1	1.049	.86	4	4.026	12.72
1¼	1.380	1.50	4½	4.506	15.95
1½	1.610	2.04	5	5.047	20.00
2	2.067	3.36	6	6.065	28.89
2½	2.469	4.79			

Table 20—Conductor Sizes and Overcurrent Protection for Motors

See Tables 26 and 27, Chapter 10

These values are in accordance with Orders 13–4309, 13–4312, 13–4322, 13–4324, 13–4342, and 13–4349, except as follows: The current values in Column 1 are to be taken from Tables 21 to 24, including footnotes, but the values shown for running protection in Columns 5 and 6 must be modified if nameplate full load current values are different, as provided in Order 13–4309. Conductor sizes shown in Columns 2 and 3 may be smaller for certain motors as provided in Order 13–4312. The current values shown in Columns 5 and 6 must be reduced by 8 per cent for all motors other than open type motors marked to have a temperature rise not over 40° C. as required by Order 13–4322. For certain exceptions to the values in Columns 7, 8, 9, and 10, see Orders 13–4342 and 13–4349. See Order 13–4343 for values to be used for several motors on one branch circuit.

Col. No. 1	2	3	5	6	7	8	9	10
					Maximum Allowable Rating or Setting of Branch Circuit Protective Devices			
Full load current rating of motor amperes	Minimum size conductor in raceways For conductors in air or for other insulations see tables 1 and 2 AWG and MCM		For Running Protection of Motors****		WITH CODE LETTERS Single-phase and squirrel cage and synchronous. Full voltage, resistor and reactor starting, Code letters F to V inc. WITHOUT CODE LETTERS Same as above.	WITH CODE LETTERS Single-phase and squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters B to E inc. Auto-transformer starting Code letters F to V inc. WITHOUT CODE LETTERS Squirrel cage and synchronous, auto-transformer starting. High reactance squirrel cage.*** Both not more than 30 amperes	WITH CODE LETTERS Squirrel cage and synchronous. Auto-transformer starting, Code letters B to E inc. WITHOUT CODE LETTERS Squirrel cage and synchronous auto-transformer starting. High reactance squirrel cage.*** Both more than 30 amperes	WITH CODE LETTERS All motors, Code letter A. WITHOUT CODE LETTERS DC and wound-rotor motors.
	Type R Type T	Type RH	Maximum rating of non-adjustable protective devices Amperes	Maximum setting of adjustable protective devices Amperes				
1**	14	14	2*	1.25*	15	15	15	15
2**	14	14	3*	2.50*	15	15	15	15
3**	14	14	4*	3.75*	15	15	15	15
4**	14	14	6*	5.0 *	15	15	15	15
5**	14	14	8*	6.25*	15	15	15	15
6**	14	14	8*	7.50*	20	15	15	15
7	14	14	10*	8.75*	25	20	15	15
8	14	14	10*	10.0 *	25	20	20	15
9	14	14	12*	11.25*	30	25	20	15
10	14	14	15*	12.50*	30	25	20	15
11	14	14	15*	13.75*	35	30	25	20
12	14	14	15	15.00	40	30	25	20
13	12	12	20	16.25	40	35	30	20
14	12	12	20	17.50	45	35	30	25
15	12	12	20	18.75	45	40	30	25
16	12	12	20	20.00	50	40	35	25
17	10	10	25	21.25	60	45	35	30
18	10	10	25	22.50	60	45	40	30
19	10	10	25	23.75	60	50	40	30
20	10	10	25	25.0	60	50	40	30
22	10	10	30	27.50	70	60	45	35
24	10	10	30	30.00	80	60	50	40
26	8	8	35	32.50	80	70	60	40
28	8	8	35	35.00	90	70	60	45

See footnotes at end of Table.

Table 20—Conductor Sizes and Overcurrent Protection for Motors (Cont'd.)

Col. No. 1	2	3	5	6	7	8	9	10
					Maximum Allowable Rating or Setting of Branch Circuit Protective Devices			
					WITH CODE LETTERS Single-phase and squirrel cage and synchronous. Full voltage, resistor and reactor starting, Code letters F to V inc. WITHOUT CODE LETTERS Same as above.	WITH CODE LETTERS Single-phase and squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters B to E inc. Auto-transformer starting Code letters F to V inc. WITHOUT CODE LETTERS Squirrel cage and synchronous, autotransformer starting. High reactance squirrel cage.*** Both not more than 30 amperes	WITH CODE LETTERS Squirrel cage and synchronous. Autotransformer starting, Code letters B to E inc. WITHOUT CODE LETTERS Squirrel cage and synchronous autotransformer starting. High reactance squirrel cage.*** Both more than 30 amperes	WITH CODE LETTERS All motors, Code letter A. WITHOUT CODE LETTERS DC and wound-rotor motors.
Full load current rating of motor amperes	Minimum size conductor in raceways For conductors in air or for other insulations see tables 1 and 2 AWG and MCM Type R Type T	Type RH	For Running Protection of Motors**** Maximum rating of non-adjustable protective devices Amperes	Maximum setting of adjustable protective devices Amperes				
30	8	8	40	37.50	90	70	60	45
32	8	8	40	40.00	100	80	70	50
34	6	8	45	42.50	110	90	70	60
36	6	8	45	45.00	110	90	80	60
38	6	6	50	47.50	125	100	80	60
40	6	6	50	50.00	125	100	80	60
42	6	6	50	52.50	125	110	90	70
44	6	6	60	55.0	125	110	90	70
46	4	6	60	57.50	150	125	100	70
48	4	6	60	60.0	150	125	100	80
50	4	6	60	62.50	150	125	100	80
52	4	6	70	65.0	175	150	110	80
54	4	4	70	67.50	175	150	110	90
56	4	4	70	70.00	175	150	120	90
58	3	4	70	72.50	175	150	120	90
60	3	4	80	75.00	200	150	120	90
62	3	4	80	77.50	200	175	125	100
64	3	4	80	80.00	200	175	150	100
66	2	4	80	82.50	200	175	150	100
68	2	4	90	85.00	225	175	150	110
70	2	3	90	87.50	225	175	150	110
72	2	3	90	90.00	225	200	150	110
74	2	3	90	92.50	225	200	150	125
76	2	3	100	95.00	250	200	175	125
78	1	3	100	97.50	250	200	175	125
80	1	3	100	100.00	250	200	175	125
82	1	2	110	102.50	250	225	175	125
84	1	2	110	105.00	250	225	175	150
86	1	2	110	107.50	300	225	175	150
88	1	2	110	110.00	300	225	200	150
90	0	2	110	112.50	300	225	200	150
92	0	2	125	115.00	300	250	200	150
94	0	1	125	117.50	300	250	200	150
96	0	1	125	120.00	300	250	200	150
98	0	1	125	122.50	300	250	200	150
100	0	1	125	125.00	300	250	200	150
105	00	1	150	131.5	350	300	225	175
110	00	0	150	137.5	350	300	225	175
115	00	0	150	144.0	350	300	250	175
120	000	0	150	150.0	400	300	250	200
125	000	00	175	156.5	400	350	250	200

Table 20—Conductor Sizes and Overcurrent Protection for Motors (Cont'd.)

Col. No. 1	2	3	5	6	7	8	9	10
					Maximum Allowable Rating or Setting of Branch Circuit Protective Devices			
					WITH CODE LETTERS Single-phase and squirrel cage and synchronous. Full voltage, resistor and reactor starting, Code letters F to V inc. WITHOUT CODE LETTERS Same as above.	WITH CODE LETTERS Single-phase and squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters B to E inc. Auto-transformer starting .Code letters F to V inc. WITHOUT CODE LETTERS Squirrel cage and synchronous, autotransformer starting. High reactance squirrel cage.*** Both not more than 30 amperes	WITH CODE LETTERS Squirrel cage and synchronous. Autotransformer starting, Code letters B to E inc. WITHOUT CODE LETTERS Squirrel cage and synchronous autotransformer starting. High reactance squirrel cage.*** Both more than 30 amperes	WITH CODE LETTERS All motors, Code letter A. WITHOUT CODE LETTERS DC and wound-rotor motors.
Full load current rating of motor amperes	Minimum size conductor in raceways For conductors in air or for other insulations see tables 1 and 2 AWG and MCM Type R Type T	Type RH	For Running Protection of Motors**** Maximum rating of non-adjustable protective devices Amperes	Maximum setting of adjustable protective devices Amperes				
130	000	00	175	162.5	400	350	300	200
135	0000	00	175	169.0	450	350	300	225
140	0000	00	175	175.0	450	350	300	225
145	0000	000	200	181.5	450	400	300	225
150	0000	000	200	187.5	450	400	300	225
155	0000	000	200	194.0	500	400	350	250
160	250	000	200	200.0	500	400	350	250
165	250	0000	225	206.	500	450	350	250
170	250	0000	225	213.	500	450	350	300
175	300	0000	225	219.	600	450	350	300
180	300	0000	225	225.	600	450	400	300
185	300	0000	250	231.	600	500	400	300
190	300	250	250	238.	600	500	400	300
195	350	250	250	244.	600	500	400	300
200	350	250	250	250.	600	500	400	300
210	400	300	250	263.	---	600	450	350
220	400	300	300	275.	---	600	450	350
230	500	300	300	288.	---	600	500	350
240	500	350	300	300.	---	600	500	400
250	500	350	300	313.	---	---	500	400
260	600	400	350	325.	---	---	600	400
270	600	400	350	338.	---	---	600	450
280	600	500	350	350.	---	---	600	450
290	700	500	350	363.	---	---	600	450
300	700	500	400	375.	---	---	600	450
320	750	600	400	400.	---	---	---	500
340	900	600	450	425.	---	---	---	600
360	1000	700	450	450.	---	---	---	600
380	1250	750	500	475.	---	---	---	600
400	1500	900	500	500.	---	---	---	600
420	1750	1000	600	525.	---	---	---	---
440	2000	1250	600	550.	---	---	---	---
460	----	1250	600	575.	---	---	---	---
480	----	1500	600	600.	---	---	---	---
500	----	1500	---	625.	---	---	---	---

*For running protection of motors of 1 horsepower or less, see order 13–4322.
**For the grouping of small motors under the protection of a single set of fuses, see order 13-4343.
***High-reactance squirrel-cage motors are those designed to limit the starting current by means of deep-slot secondaries or double-wound secondaries and are generally started on full voltage.
****For the running protection of motors, see order 13–4322.

Table 21—Full-Load Current*

Direct-Current Motors

HP	115V	230V	550V
½	4.6	2.3	
¾	6.6	3.3	1.4
1	8.6	4.3	1.8
1½	12.6	6.3	2.6
2	16.4	8.2	3.4
3	24.	12.	5.0
5	40.	20.	8.3
7½	58.	29.	12.0
10	76.	38.	16.0
15	112.	56.	23.0
20	148.	74.	31.
25	184.	92.	38.
30	220.	110.	46.
40	292.	146.	61.
50	360.	180.	75.
60	430.	215.	90.
75	536.	268.	111.
100		355.	148.
125		443.	184.
150		534.	220.
200		712.	295.

*These values for full-load current are average for all speeds.

Table 22—Full-Load Current*

Single-Phase A.C. Motors

HP	115V	230V	440V
1/6	3.2	1.6	
¼	4.6	2.3	
½	7.4	3.7	
¾	10.2	5.1	
1	13.	6.5	
1½	18.4	9.2	
2	24.	12.	
3	34.	17.	
5	56.	28.	
7½	80.	40.	21.
10	100.	50.	26.

For full-load currents of 208 and 200-volt motors, increase corresponding 230-volt motor full-load current by 10 and 15 per cent, respectively.

*These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used.

Table 23—Full-Load Current*

Two-Phase A.C. Motors (4-wire)

	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
HP	110V	220V	440V	550V	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	8.8	4.4	2.2	1.8					
2	11.2	5.6	2.8	2.2					
3		8	4	3.2					
5		13	7	6					
7½		19	9	8					
10		24	12	10					
15		34	17	14					
20		45	23	18					
25		55	28	22	6	47	24	19	4.7
30		67	34	27	7.5	56	29	23	5.7
40		88	44	35	9	75	37	31	7
50		108	54	43	11	94	47	38	9
60		129	65	52	13	111	56	44	11
75		158	79	63	16	140	70	57	13
100		212	106	85	21	182	93	74	17
125		268	134	108	26	228	114	93	22
150		311	155	124	31		137	110	26
200		415	208	166	41		182	145	35

*These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used. Current in common conductor of 2-phase, 3-wire system will be 1.41 times value given.

†For 90 and 80 per cent P. F. the above figures should be multiplied by 1.1 and 1.25 respectively.

Table 24—Full-Load Current*

Three-Phase A.C. Motors

	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
HP	110V	220V	440V	550V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	5.6	2.8	1.4	1.1					
1	7	3.5	1.8	1.4					
1½	10	5	2.5	2.0					
2	13	6.5	3.3	2.6					
3		9	4.5	4					
5		15	7.5	6					
7½		22	11	9					
10		27	14	11					
15		40	20	16					
20		52	26	21					
25		64	32	26	7	54	27	22	5.4
30		78	39	31	8.5	65	33	26	6.5
40		104	52	41	10.5	86	43	35	8
50		125	63	50	13	108	54	44	10
60		150	75	60	16	128	64	51	12
75		185	93	74	19	161	81	65	15
100		246	123	98	25	211	106	85	20
125		310	155	124	31	264	132	106	25
150		360	180	144	37		158	127	30
200		480	240	192	48		210	168	40

For full-load currents of 208 and 200 volt motors, increase the corresponding 220-volt motor full-load current by 6 and 10 per cent, respectively.

*These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used.

†For 90 and 80 per cent P. F. the above figures should be multiplied by 1.1 and 1.25 respectively.

Table 26—Maximum Rating or Setting of Motor-Branch-Circuit Protective Devices for Motors Marked with a Code Letter Indicating Locked Rotor KVA

	Per Cent of Full-Load Current		
	Fuse Rating (See also Table 20, Columns 7, 8, 9, 10)	Circuit-Breaker Setting Instantaneous Type	Circuit-Breaker Setting Time Limit Type
Type of Motor			
All AC single-phase and polyphase squirrel cage and synchronous motors with full-voltage, resistor or reactor starting:			
Code Letter A	150	---	150
Code Letter B to E	250	---	200
Code Letter F to V	300	---	250
All AC squirrel cage and synchronous motors with auto-transformer starting:			
Code Letter A	150	---	150
Code Letter B to E	200	---	200
Code Letter F to V	250	---	200

For certain exceptions to the values specified see orders 13–4342 and 13–4349. The values given in the last column also cover the ratings of non-adjustable, time-limit types of circuit-breakers which may also be modified as in order 13–4342.

Synchronous motors of the low-torque, low-speed type (usually 450 RPM or lower), such as are used to drive reciprocating compressors, pumps, etc., which start up unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 per cent of full-load current.

For motors not marked with a Code Letter, see Table 27.

Table 27—Maximum Rating or Setting of Motor-Branch-Circuit Protective Devices for Motors not Marked with a Code Letter Indicating Locked Rotor KVA

	Per Cent of Full-Load Current		
	Fuse Rating (See also Table 20, Columns 7, 8, 9, 10)	Circuit-Breaker Setting Instantaneous Type	Circuit-Breaker Setting Time Limit Type
Type of Motor			
Single-phase, all types	300	---	250
Squirrel-cage and synchronous (full-voltage, resistor and reactor starting)	300	---	250
Squirrel-cage and synchronous (auto-transformer starting)			
Not more than 30 amperes	250	---	200
More than 30 amperes	200	---	200
High-reactance squirrel-cage			
Not more than 30 amperes	250	---	250
More than 30 amperes	200	---	200
Wound-rotor	150	---	150
Direct-current			
Not more than 50 H.P.	150	250	150
More than 50 H.P.	150	175	150

For certain exceptions to the values specified see orders 13–4342 and 13–4349. The values given in the last column also cover the ratings of non-adjustable, time-limit types of circuit-breakers which may also be modified as in order 13–4342.

Synchronous motors of the low-torque low-speed type (usually 450 R.P.M. or lower) such as are used to drive reciprocating compressors, pumps, etc., which start up unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 per cent of full-load current.

For motors marked with a Code Letter, see Table 26.

Table 28—Number of Overcurrent Units, Such as Trip Coils or Relays, for Protection of Circuits

(See Diagrams 1 to 19)

(See Order 13–2405 for the overcurrent protection of conductors in general, Order 13–2371 for Services and Order 13–4327 for Motors)

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

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

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

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

Table 29—Demand Loads for Household Electric Ranges and Other Household Cooking Appliances Over 1¾ kw Rating

Column A to be used in all cases except as otherwise permitted in Note 4 below

Number of Ranges	Maximum Demand (See Notes)	Demand Factors (See Note 4)	
	COLUMN A (Not over 12 kw Rating)	COLUMN B (Less than 3½ kw Rating)	COLUMN C (3½ kw to 8¾ kw Rating)
1	8 kw	80%	80%
2	11 kw	75%	65%
3	14 kw	70%	55%
4	17 kw	66%	50%
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 and over	range	30%	16%

Note 1. Over 12 kw to 21 kw ranges all of same kw rating. For ranges, individually rated more than 12 kw but not more than 21 kw, the maximum demand in Column A shall be increased 5 per cent for each additional kw of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kw.

Note 2. Over 12 kw to 21 kw ranges of unequal ratings. For ranges individually rated more than 12 kw and of different ratings but none exceeding 21 kw an average value of rating shall be calculated by adding together the ratings of all ranges to obtain the total connected load (using 12 kw for any range rated less than 12 kw) and dividing by the total number of ranges; and then the maximum demand in Column A shall be increased 5 per cent for each kw or major fraction thereof by which this average value exceeds 12 kw.

Note 3. Generally, the demand for commercial ranges should be based on the maximum nameplate rating.

Note 4. Over 1¾ kw to 8¾ kw. In lieu of the method provided in Column A, the load for ranges individually rated more than 1¾ kw but not more than 8¾ kw may be considered as the sum of the nameplate ratings of all the ranges, multiplied by the demand factors specified in Columns B or C for the given number of ranges.

Note 5. Branch Circuit Load. Branch circuit load for one range may be computed in accordance with the above table.

(See examples 6 and 7.)

Table 30—Capacitor Ratings for Use With Open-Type Three-Phase Sixty Cycle Induction Motors

See Order 13-4606

Motor Rating HP	3600 RPM*		1800 RPM*		1200 RPM*		900 RPM*		720 RPM*		600 RPM*	
	Max. Capacitor Rating Kva	Reduction in Line Current %	Max. Capacitor Rating Kva	Reduction in Line Current %	Max. Capacitor Rating Kva	Reduction in Line Current %	Max. Capacitor Rating Kva	Reduction in Line Current %	Max. Capacitor Rating Kva	Reduction in Line Current %	Max. Capacitor Rating Kva	Reduction in Line Current %
10	2.5	9	4.	11	4.	12	5.	17	5.	23	7.5	28
15	2.5	9	5.	11	5.	11	7.5	16	7.5	21	10.	26
20	5.	9	5.	10	5.	11	7.5	15	10.	20	12.5	24
25	5.	9	7.5	10	7.5	10	10.	14	10.	19	15.	22
30	7.5	9	10.	9	10.	10	10.	13	12.5	18	15.	21
40	10.	9	10.	9	10.	10	12.5	12	15.	16	17.5	19
50	12.5	9	12.5	9	12.5	9	15.	12	20.	15	22.5	17
60	15.	9	15.	8	15.	9	17.5	11	22.5	14	25.	16
75	17.5	9	17.5	8	17.5	8	20.	11	27.5	13	30.	15
100	22.5	9	22.5	8	22.5	8	25.	10	35.	12	37.5	14
125	25.	9	27.5	8	27.5	8	30.	9	40.	11	47.5	13
150	32.5	9	35.	8	35.	8	37.5	9	47.5	11	55.	13
200	42.5	9	42.5	8	42.5	8	45.	9	60.	10	67.5	12

*Synchronous speed.

If capacitors of a lower rating than the values given in the table are used, the percentage reduction in line current given in the table shall be reduced a corresponding amount.

Table 31—Flexible Cord

(See Order 13-4002)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Asbestos Covered Tinsel Cord	AT See Note 3	27	2 or 3	Rubber and Asbestos	Cotton	None	Attached to a Device	Dry Places	Not Hard Usage
					None	Cotton or Rayon			
Cotton Covered Tinsel Cord	CT See Note 3	27	2 or 3	Rubber	Cotton	Cotton or Rayon	Attached to a Device	Dry Places	Not Hard Usage
Rubber Jacketed Tinsel Cord	ATJ See Note 3	27	2 or 3	Rubber and Asbestos	None	Rubber	Attached to a Device	Damp Places	Not Hard Usage
	CTJ See Note 3			Rubber	Cotton				
Asbestos-Covered Heat-Resistant Cord	AFC	18, 16 14	2 or 3	Impregnated Asbestos	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
	AFPO		2			Cotton, Rayon or Saturated Asbestos			
	AFPD		2 or 3		None				
Cotton-Covered Heat-Resistant Cord	CFC	18, 16 14	2 or 3	Impregnated Cotton	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
	CFPO		2			Cotton or Rayon			
	CFPD		2 or 3		None				

See Notes at end of Table.

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Parallel Cord	PO–64	18	2	Rubber	Cotton	Cotton or Rayon	See Note 2	Dry Places	Not Hard Usage
	PO–32	18, 16					Pendant or Port.		
	PO	14 and over							
All Rubber Parallel Cord	POSJ–64	18	2	Rubber	None	Rubber	Pendant or Portable	Damp Places	Not Hard Usage
	POSJ–32	18, 16							
All Plastic Parallel Cord	POT–64	18	2	Thermoplastic	None	Thermoplastic	Pendant or Portable	Damp Places	Not Hard Usage
	POT–32	18, 16							
Lamp Cord	C	18 and over	2 or more	Rubber	Cotton	None	Pendant or Port.	Dry Places	Not Hard Use
Armored Cord	CA	18, 16 14	2	Rubber	Cotton	Fibrous and Metal Armor	Pendant or Port.	Dry Places	Hard Usage
Twisted Portable Cord	PD	18 and over	2 or more	Rubber	Cotton	Cotton or Rayon	Pendant or Port.	Dry Places	Not Hard Usage
Reinforced Cord	P–64	18	2 or more	Rubber	Cotton	Cotton over Rubber Filler	Pendant or Portable	Dry Places	Not Hard Use
	P–32	18, 16							
	P	14 and over							Hard Usage

See Notes at end of Table.

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Moisture-Proof Reinforced Cord	PWP–64	18	2 or more	Rubber	Cotton	Cotton, Moisture-Resistant Finish over Rubber Filler	Pendant or Portable	Damp Places	Not Hard Use
	PWP–32	18, 16							
	PWP	14 and over							Hard Usage
Braided Heavy Duty Cord	K See Note 4	18 and over	2 or more	Rubber	Cotton	Two Cotton, Moisture-Resistant Finish See Note 5	Pendant or Portable	Damp Places	Hard Usage
Vacuum Cleaner Cord	SV	18	2	Rubber	None	Rubber	Pendant or Portable	Damp Places	Hard Usage
	SVT			Thermoplastic		Thermoplastic			
Junior Hard Service Cord	SJ	18, 16	2, 3 or 4	Rubber	None	Rubber	Pendant or Portable	Damp Places	Hard Usage
	SJO					Oil Resist. Compound			
	SJT			Thermoplastic		Thermoplastic			
Hard Service Cord	S See Note 6	18 to 10 incl.	2 or more	Rubber	None	Rubber	Pendant or Portable	Damp Places	Extra Hard Usage
	SO					Oil Resist. Compound			
	ST			Thermoplastic		Thermoplastic			
	SU			90% Unmilled Grainless Rubber	Cotton or Rayon	Rubber			
	SUO					Oil Resist. Compound			

See Notes at end of Table.

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
							Portable	Damp Places	Portable Heaters
Rubber-Jacketed Heat-Resistant Cord	AFSJ	18, 16	2 or 3	Impregnated Asbestos	None	Rubber	Portable	Damp Places	Portable Heaters
	AFS	18, 16, 14							
Heater Cord	HC	18, 17, 16, 15, 14	2 or more	Rubber and Asbestos	Cotton	None	Portable	Dry Places	Portable Heaters
	HPD				None	Cotton or Rayon			
Rubber Jacketed Heater Cord	HSJ	18, 17, 16, 15, 14	2 or more	Rubber and Asbestos	None	Cotton and Rubber	Portable	Damp Places	Portable Heaters
Heat and Moisture Resistant Cord	AVPO	18 to 10 incl.	2	Asbestos and Var. Camb.	None	Asbestos, Flame- Ret. Moisture Resistant	Pendant or Portable	Damp Places	Not Hard Usage
	AVPD		2 or 3						
Elevator Cable	E See Note 7	18 and over	2 or more	Rubber	Cotton	Three Cotton, Outer one Flame Retardant and Moisture Resist. See Note 5	Elevator Lighting and Control	Non-Hazardous Locations	
	EO See Note 7					One Cotton and a Neoprene Jacket See Note 5		Hazardous Locations	
	ET See Note 7	16 and over		Thermoplastic	Rayon	Three Cotton, Outer one Flame Retardant and Moisture Resistant. See Note 5		Non-Hazardous Locations	

See Notes on next page.

NOTES TO TABLE 31

1. Except for types AFPO, CFPO, PO–64, PO–32, PO, POSJ–64 and POSJ–32, and POT–64, POT–32, and AVPO individual conductors are twisted together.
2. Type PO–64 is for use only with portable lamps, portable radio receiving appliances, portable clocks and similar appliances which are not liable to be moved frequently and where appearance is a consideration.
3. Types AT, CT, ATJ and CTJ are suitable for use in lengths not exceeding eight feet when attached directly, or by means of a special type of plug, to a portable appliance rated at 50 watts or less and of such a nature that extreme flexibility of the cord is essential. Types AT and ATJ are for use only with heating appliances.
4. Type K is suitable for use on theatre stages.
5. Rubber-filled or varnished cambric tapes may be substituted for the inner braids.
6. Types S, SO, SU, SUO and ST are suitable for use on theatre stages, in garages and elsewhere where flexible cords are permitted by this code.
7. Types E and EO may have a composite assembly of steel and copper strands in the make-up of the individual conductors or may have one or more supporting fillers of cotton or hemp rope, or of cotton-covered or rubber-covered steel wire laid up with the conductors under the outer covering of the cable. In cables containing six or more conductors the steel supporting strands shall run straight through and not be cabled with the conductors.

Table 32—Isolation by Elevation

(See Order 13–7162)

Distance of Live Parts Above the Floor or Other Working Surface

Voltage Between Phases	Minimum Vertical Clearance of Unguarded Parts Feet	Inches
600	8	0
2300	8	0
6600	8	0
11000	9	0
22000	9	3
33000	9	6
44000	9	10
66000	10	5
88000	11	0
110000	11	7
132000	12	2

Table 33—Working Space

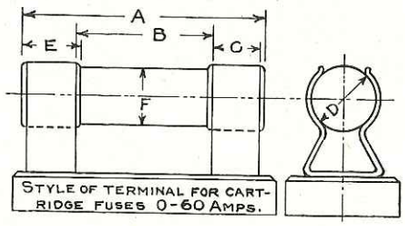
(See Order 13–7163. For voltages below 600, see Order 13–1112)

Minimum Clear Space Adjacent to Live Parts

Voltage Between Phases	Minimum Horizontal Clearance of Unguarded Parts Feet	Inches
600	3	2
2300	3	3
6600	3	4
11000	3	6
22000	3	9
33000	4	0
44000	4	4
66000	4	11
88000	5	6
110000	6	1
132000	6	8

Table 34—Table of Dimensions of the National Electrical Code Standard Cartridge Enclosed Fuses

(See Order 13–92401)

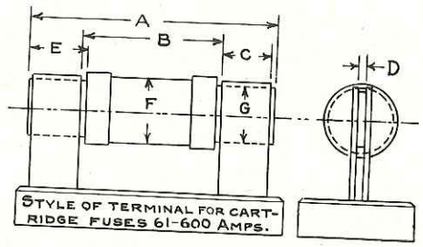


Form 1. CARTRIDGE FUSE—Ferrule Contact

Voltage	Rated Capacity Amperes		A Length Over Terminals Inches	B Distance between Contact Clips Inches	C Width of Contact Clips Inches
Not over 250	0–30	Form 1	2	1	1/2
	31–60		3	1 3/4	5/8
	61–100	Form 2	5 7/8	4	7/8
	101–200		7 1/8	4 1/2	1 1/4
	201–400		8 5/8	5	1 3/4
	401–600		10 3/8	6	2 1/8
Not over 600	0–30	Form 1	5	4	1/2
	31–60		5 1/2	4 1/4	5/8
	61–100	Form 2	7 7/8	6	7/8
	101–200		9 5/8	7	1 1/4
	201–400		11 5/8	8	1 3/4
	401–600		13 3/8	9	2 1/8

Table 34—Table of Dimensions of the National Electrical Code Standard Cartridge Enclosed Fuses (Cont'd)

(See Order 13–92401)



Form 2. CARTRIDGE FUSE—Knife Blade Contact

D Diameter of Ferrules or Thickness of Terminal Blades Inches	E Min. Length of Ferrules or of Terminal Blades outside of Tube Inches	G Width of Terminal Blades Inches		Rated Capacity Amperes
9/16	1/2		Form 1	0–30
13/16	5/8			31–60
1/8	1	3/4	Form 2	61–100
3/16	1 3/8	1 1/8		101–200
1/4	1 7/8	1 5/8		201–400
1/4	2 1/4	2		401–600
13/16	1/2		Form 1	0–30
1–1/16	5/8			31–60
1/8	1	3/4	Form 2	61–100
3/16	1 3/8	1 1/8		101–200
1/4	1 7/8	1 5/8		201–400
1/4	2 1/4	2		401–600

DIAGRAMS

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

** See Note 2 Table 28.

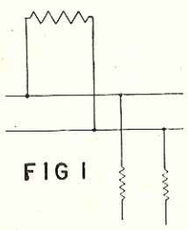


FIG 1

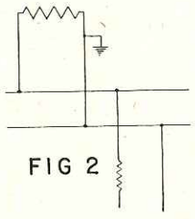


FIG 2

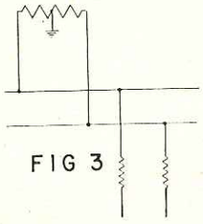


FIG 3

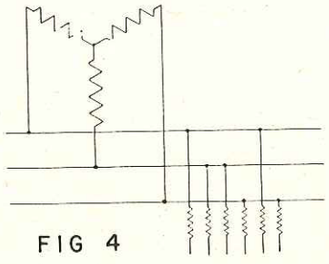


FIG 4

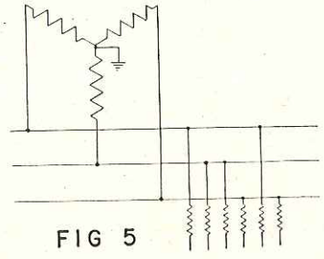


FIG 5

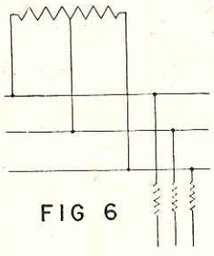


FIG 6

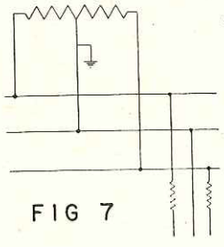


FIG 7

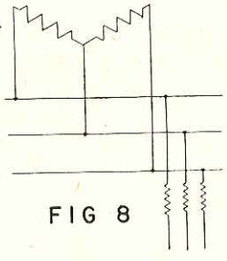


FIG 8

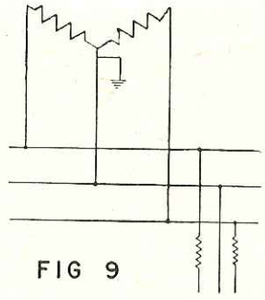


FIG 9

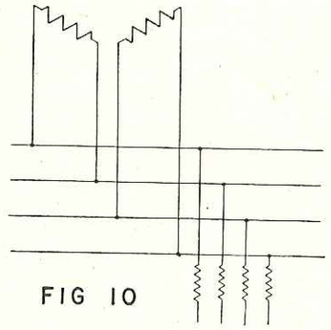


FIG 10

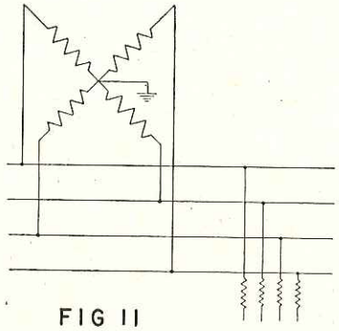


FIG 11

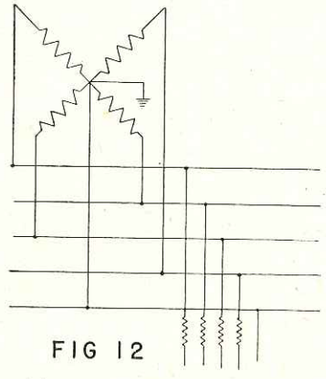


FIG 12

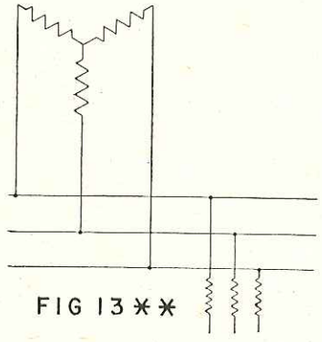


FIG 13**

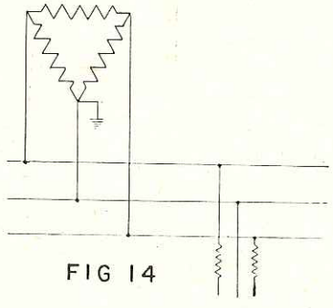


FIG 14

** See Note 2 of Table 28.

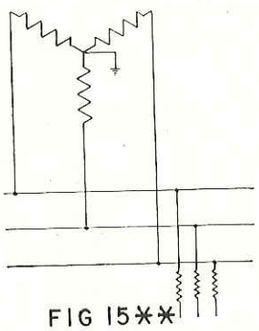


FIG 15**

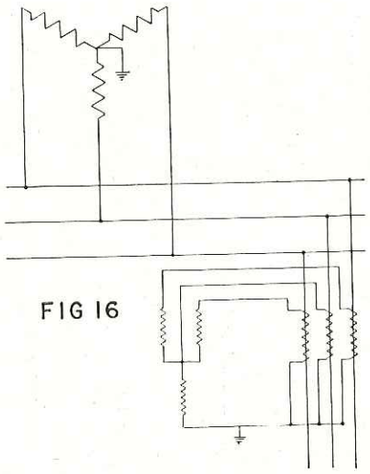


FIG 16

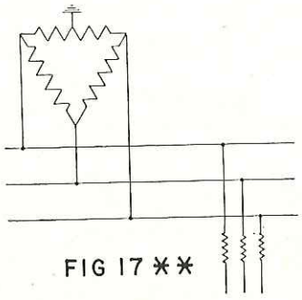


FIG 17 **

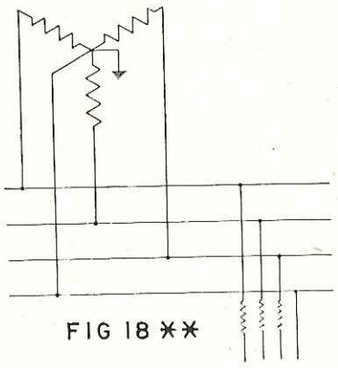


FIG 18 **

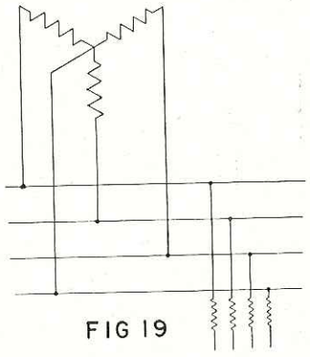


FIG 19

** See Note 2 of Table 28.

MOTOR FEEDER AND BRANCH CIRCUITS

Section 13-430

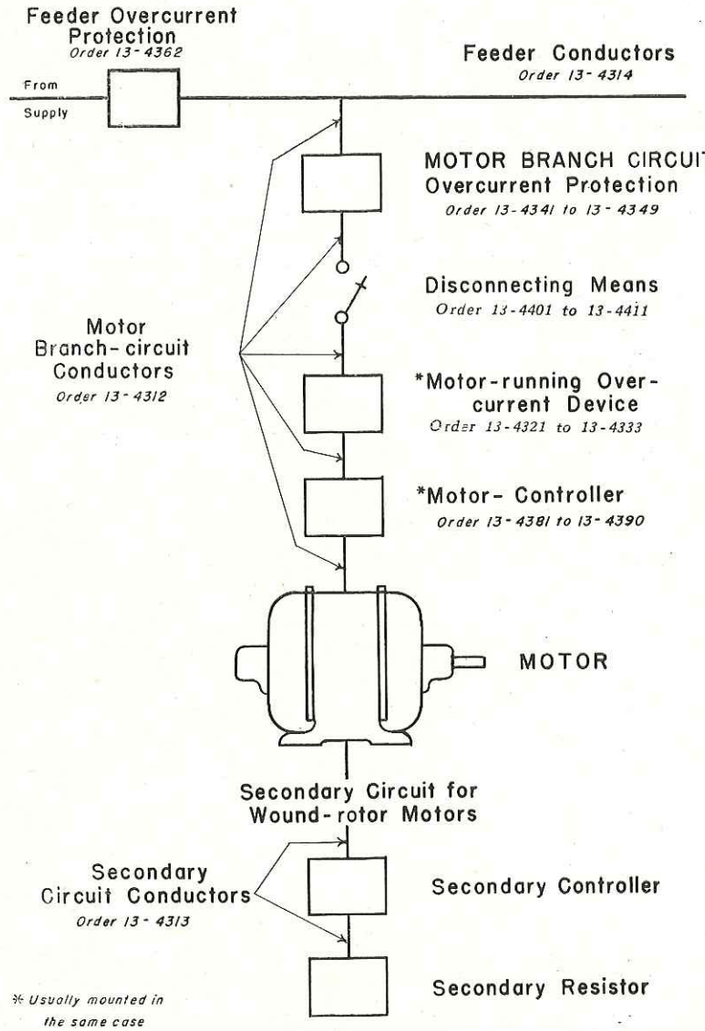


Fig. 20

Examples

SELECTION OF CONDUCTORS. In the following examples the size of conductor has been selected on the basis of the allowable current-carrying capacities tabulated in the second column of Table 1. If other types of insulated conductors are used, or if the conductors are run open, or with more than three conductors in a raceway, the size of conductor may vary from those shown. Tables 1 and 2 should be consulted in selecting the size of conductor for a particular installation.

VOLTAGE. For uniform application of the provisions of Sections 13–210 and 13–220, a nominal voltage of 115 and 230 volts shall be used in computing the ampere load on the conductor.

FRACTIONS OF AN AMPERE. Where the computations result in a fraction of an ampere, such fractions may be dropped.

RANGES. For the computation of the range loads in these examples Column A of Table 29 has been used. For optional method, see Columns B and C of Table 29.

Example No. 1. Single Family Dwelling

Dwelling has a floor area of 2,500 square feet, exclusive of unoccupied cellar, unfinished attic and open porches. It has a 12 kw range.

COMPUTED LOAD (Order 13–2203):

General lighting load:

2,500 square feet at 3 watts per square foot ---------- 7,500 watts

MINIMUM NUMBER OF BRANCH CIRCUITS REQUIRED (Order 13–2115):

General lighting load: 7,500 ÷ 115 = 65 amperes, or five 15-ampere 2-wire circuits; or four 20-ampere 2-wire circuits.

Small appliance load: One 2-wire circuit of No. 12 wire. (See Order 13–2115–B).

MINIMUM SIZE FEEDERS (OR SERVICE CONDUCTORS) REQUIRED (Order 13–2201):

Computed load (Order 13–2203):

General lighting load	7,500 watts
Small appliance load (See Order 13–2203 C–1).	1,500 watts
Total computed load (without range)	9,000 watts
3,000 watts at 100%	3,000 watts
9,000 minus 3,000 = 6,000 watts at 35%	2,100 watts
Net computed load (without range)	5,100 watts
Range load (See Table 29 Column A)	8,000 watts
Net computed load (with range)	13,100 watts

For 115/230 volt, 3-wire system:

13,000 ÷ 230 = 57 amperes. (See Orders 13–2201 and 13–2304 for minimum size conductor) Use No. 4 service conductors.

MINIMUM NUMBER RECEPTACLES REQUIRED (Order 13–2124):

LIVING ROOM: 16 feet by 22 feet; 76 feet total (gross) distance around the room. 76 feet ÷ 20 = 3.8 or 4 receptacles.

EACH BED ROOM: 14 feet by 15 feet; 58 feet total (gross) distance around the room. 58 feet ÷ 20 = 2.9 or 3 receptacles.

*DINING ROOM: 16 feet by 16 feet; 64 feet total (gross) distance around the room. 64 feet ÷ 20 = 3.2 or 3 receptacles.

*BREAKFAST ROOM: 10 feet by 12 feet; 44 feet total (gross) distance around the room. 44 feet ÷ 20 = 2.2 or 2 receptacles.

*KITCHEN: 14 feet by 14 feet; 56 feet total (gross) distance around the room. 56 feet ÷ 20 = 2.8 or 3 receptacles.

NOTE 1. Receptacles to be placed equal distances apart insofar as practicable

*NOTE 2. Receptacles in these locations, also laundry, to be supplied by circuit or circuits of not less than No. 12 wire, (Order 13–2115).

Example No. 2. Small Roadside Fruitstand With No Show Windows

A small roadside fruitstand with no show windows has a floor area of 150 square feet. The electrical load consists of general lighting and a 1000 watt floodlight. There are no other outlets.

COMPUTED LOAD (Order 13–2203)

*General Lighting

150 Sq. ft. at 3 watts/sq. ft. × 1.25 = 562 watts (3 watts/sq. ft. for stores)

562 watts ÷ 115 = 488 amperes

One 15 ampere 2 wire branch circuit required (Order 13–2116–A–1)

MINIMUM SIZE SERVICE CONDUCTOR REQUIRED (Order 13–2304–A–1)

Computed load	562 watts
Floodlight load	1000 watts
Total load	1562 watts

1562 ÷ 115 = 13.6 amperes

Use No. 8 service conductor (Order 13–2304–A–1)

Use a 30 ampere service switch or breaker (Order 13–2357).

Example No. 3. Store Building

A store 50 feet by 60 feet, or 3,000 square feet, has 30 feet of show window.

COMPUTED LOAD: (Order 13–2203):

*General lighting load:

3,000 square feet at 3 watts per square foot × 1.25 ---- 11,250 watts

**Show window lighting load:

30 feet at 200 watts per foot ---------- 6,000 watts

MINIMUM NUMBER OF BRANCH CIRCUITS REQUIRED (Order 13–2115):

***General lighting load: 11,250 ÷ 230 = 49 amperes for 3 wire, 115/230 volts; or 98 amperes for 2 wire, 115 volts:

Three 30 ampere, 2-wire; and one 15 ampere, 2-wire circuits; or
Five 20 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire, and three 15 ampere, 2-wire circuits; or
Seven 15 ampere, 2-wire, circuits; or
Three 15 ampere, 3-wire, and one 15 ampere, 2-wire circuits.

Special lighting load (show window): (Orders 13–2116–C–2 and 13–2203–B): 6,000 ÷ 230 = 26 amperes for 3-wire, 115/230 volt; or 52 amperes for 2-wire, 115 volts:

Four 15 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire circuits; or
Two 15 ampere, 3-wire circuits.

MINIMUM SIZE FEEDERS (OR SERVICE CONDUCTORS) REQUIRED (Order 13–2201):

For 115/230 volt, 3-wire system:

Ampere load: 49 plus 26 = 75 amperes. (Order 13–2203):

Size of each feeder, No. 3

For 115 volt system:

Ampere load: 98 plus 52 = 150 amperes. (Order 13–2203)

Size of each feeder, No. 3/0

See next page for footnote references.

*The above examples assume that the entire general lighting load is likely to be used for long periods of time and the load is therefore increased by 25 per cent in accordance with Order 13–2116. The 25 per cent increase is not applicable to any portion of the load not used for long periods.

**If show window load computed as per paragraph 13–2116B, the unit load per outlet to be increased 25 per cent.

***The load on individual branch circuits not to exceed 80% of the branch circuit rating (Order 13–2125–B).

Example No. 4. Multi-Family Dwelling

Multi-family dwelling having a total floor area of 32,000 square feet with 40 apartments.

Meters in two banks of 20 each and individual sub-feeders to each apartment.

One-half of the apartments are equipped with electric ranges of not exceeding 12 kw each.

Area of each apartment is 800 square feet.

COMPUTED LOAD FOR EACH APARTMENT (Order 13–2203):

General lighting load:	
800 square feet at 3 watts per square foot	2,400 watts
Special appliance load:	
Electric range	8,000 watts

MINIMUM NUMBER OF BRANCH CIRCUITS REQUIRED FOR EACH APARTMENT (Order 13–2115):

General lighting load: 2,400 ÷ 115 = 21 amperes or two 15 ampere, 2-wire circuits; or two 20 ampere, 2-wire circuits.

Small appliance load: One 2-wire circuit of No. 12 wire (See Order 13–2115–B).

Range Circuit: 8,000 ÷ 230 = 34 amperes or a circuit of two No. 8's and one No. 10 as permitted by Order 13–2121–C–1.

MINIMUM SIZE SUB-FEEDER REQUIRED FOR EACH APARTMENT (Order 13–2201):

COMPUTED LOAD (Order 13–2203):

General lighting load	2,400 watts
Small appliance load	1,500 watts
Total computed load (without ranges)	3,900 watts
Application of Demand Factor	
3,000 watts at 100%	3,000 watts
900 watts at 35%	315 watts
Net computed load (without ranges)	3,315 watts
Range load	8,000 watts
Net computed load (with ranges)	11,315 watts

FOR 115-230 VOLT, 3 WIRE SYSTEM (WITHOUT RANGES):
Net computed load 3,315 ÷ 230 = 14 amperes
Size of each sub-feeder, No. 10 (See Order 13–2201).

FOR 115-230 VOLT, 3 WIRE SYSTEM (WITH RANGES):
Net computed load 11,315 ÷ 230 = 49 amperes
Size of each ungrounded sub-feeder, No. 6

Neutral Sub-feeder:

Lighting and small appliance load	3,315 watts
Range load 8,000 watts at 70% (See Order 13–2203–G)	5,600 watts
Net computed load (neutral)	8,915 watts

8,915 ÷ 230 = 39 amperes
Size of neutral sub-feeder, No. 8.

MINIMUM SIZE FEEDERS REQUIRED FROM SERVICE EQUIPMENT TO METER BANK (FOR 20 APARTMENTS—10 WITH RANGES):

Total Computed Load:	
Lighting and small appliance load, 20 × 3,900	78,000 watts
Application of Demand Factor	
3,000 watts at 100%	3,000 watts
75,000 watts at 35%	26,250 watts
Net computed lighting and small appliance load	29,250 watts
Range load, 10 ranges (Less than 12 kw; Col. A. Table 29)	25,000 watts
Net computed load (with ranges)	54,250 watts

FOR 115/230 VOLT, 3 WIRE SYSTEM:
Net computed load: 54,250 ÷ 230 = 236 amperes
Size of each ungrounded feeder to each meter bank: 300,000 C.M.

Neutral Feeder:

Lighting and small appliance load	29,250 watts
Range load, 25,000 watts at 70% (See Order 13–2203G).	17,500 watts
Computed load (neutral)	46,750 watts

46,750 ÷ 230 = 203 amperes.

Further Demand Factor (Order 13–2203G):
200 amperes at 100% = 200 amperes
3 amperes at 70% = 2 amperes
Net computed load (neutral) 202 amperes
Size of neutral feeder to each meter bank ---------- 250,000 C.M.

MINIMUM SIZE MAIN FEEDER (OR SERVICE CONDUCTORS) REQUIRED (FOR 40 APARTMENTS—20 WITH RANGES):

Total Computed Load:	
Lighting and small appliance load, 40 × 3,900	156,000 watts
Application of Demand Factor:	
3,000 watts at 100%	3,000 watts
117,000 watts at 35%	40,950 watts
36,000 watts at 25%	9,000 watts
Net computed lighting and small appliance load	52,950 watts
Range load, 20 ranges (Less than 12 kw, Col. A, Table 29)	35,000 watts
Net computed load	87,950 watts

FOR 115/230 VOLT, 3 WIRE SYSTEM:
Net computed load 87,950 ÷ 230 = 382 amperes.
Size of each ungrounded main feeder: 700,000 C.M.

Neutral Feeder:

Lighting and small appliance load	52,950 watts
Range load, 35,000 watts at 70% (See Order 13–2203G)	24,500 watts
Computed load (neutral)	77,450 watts

77,450 ÷ 230 = 337 amperes.

Further Demand Factor (See Order 13–2203G):
200 amperes at 100% = 200 amperes
137 amperes at 70% = 96 amperes
Net computed load (neutral) = 296 amperes
Size of neutral main feeder ---------- 500,000 C.M.
See Notes 2 and 5 to Tables 1 and 2.

Example No. 5. Calculation of Neutral Feeder

(See Order 13–2203)

The following example illustrates the method of calculating size of neutral feeder for the computed load of a 5-wire, 2-phase system, where it is desired to modify the load in accordance with provisions of Order 13–2203.

An installation consisting of a computed load of 250 amperes connected between neutral feeder and each ungrounded feeder.

Neutral feeder (maximum unbalance of load

250 amp. × 140% = 350 amperes):

200 amperes (first)	at 100% =	200 amperes
150 amperes (excess)	at 70% =	105 amperes
Computed load		305 amperes

Size of neutral feeder: 500,000 C.M.

Example No. 6. Maximum Demand for Range Loads

Table 29, Column A applies to ranges not over 12 kw. The application of Note 1 to ranges over 12 kw (and not over 21 kw) is illustrated in the following examples:

A. *Ranges all of same rating.*

Assume 24 ranges each rated 16 kw.

From Column A the maximum demand for 24 ranges of 12 kw rating is 39 kw.

16 kw. exceeds 12 kw by 4.

5% × 4 = 20% (5% increase for each kw in excess of 12).

39 kw × 20% = 7.8 kw increase.

39 + 7.8 = 46.8 = value to be used in selection of feeders.

B. *Ranges of unequal rating.*

Assume 5 ranges each rated 11 kw.
2 ranges each rated 12 kw.
20 ranges each rated 13.5 kw.
3 ranges each rated 18 kw.

5 × 12	=	60	Use 12 kw for range rated less than 12.
2 × 12	=	24	
20 × 13.5	=	270	
3 × 18	=	54	
		408	kw

408 ÷ 30 = 13.6 kw (average to be used for computation)

From Column A the demand for 30 ranges of 12 kw rating is 15 + 30 = 45 kw.

13.6 exceeds 12 by 1.6 (use 2).

5% × 2 = 10% (5% increase for each kw in excess of 12).

45 kw × 10% = 4.5 kw increase.

45 + 4.5 = 49.5 kw = value to be used in selection of feeders.

Example No. 7. Ranges on a 3-Phase System

(Order 13–2203–D)

Thirty ranges rated at 12 kw each are supplied by a 3-phase, 4-wire, 120/208-volt feeder, 10 ranges on each phase.

As there are 20 ranges connected to each ungrounded conductor, the load should be calculated on the basis of 20 ranges (or in case of unbalance, twice the maximum number between any two phase wires) since diversity applies only to the number of ranges connected to adjacent phases and not the total.

The current in any one conductor will be one-half the total watt load of two adjacent phases divided by the line-to-neutral voltage. In this case, 20 ranges, from Table 29, Chapter 10, will have total watt load of 35,000 watts for two phases; therefore, the current in the feeder conductor would be:

17,500 ÷ 120 = 146 amperes.

On a three-phase basis the load would be:

3 × 17,500 = 52,500 watts

and the current in each feeder conductor—

$$\frac{52{,}500}{208 \times 1.73} = 146 \text{ amperes.}$$

Example No. 8. Motors, Conductors, and Overcurrent Protection

(See Orders 13–4312, 13–4314, 13–4322 and 13–4342)

Determine the size of conductors, the motor-running overcurrent protection, the branch circuit protection, and the feeder protection, for one 25-h.p. squirrel-cage induction motor (full-voltage starting), and two 30-h.p. wound-rotor induction motors, on a 440-volt, 3-phase, 60-cycle supply.

Conductor Sizes

The full-load current of the 25-h.p. motor is 32 amperes (Table 24). A full-load current of 32 amperes requires a No. 8, Type R, rubber-covered conductor (Column 2, Table 20). The full-load current of the 30-h.p. motor is 39 amperes (Table 24). A full-load current of 39 amperes requires a No. 6, Type R, rubber-covered conductor (Column 2, Table 20).

The feeder conductor capacity will be 125 per cent of 39, plus 39, plus 32, or 120 amperes (Order 13–4314). In accordance with Table 1, this would require a No. 0, Type R, rubber-covered feeder.

Note. For Type R conductors run open in air, or for conductors with insulations other than Type R, see Tables 1 and 2.

Overcurrent Protection

Running. The 25-h.p. motor, with full-load current of 32 amperes, must have running overcurrent protection of not over 40 amperes (Columns 5 and 6, Table 20). The 30-h.p. motor with full-load current of 39 amperes must have running overcurrent protection of not over 50 amperes (Columns 5 and 6, Table 20).

Branch Circuit. The branch circuit of the 25-h.p. motor must have branch-circuit overcurrent protection of not over 100 amperes (Column 7, Table 20). The branch circuit of the 30-h.p. motor must have branch-circuit overcurrent protection of not over 60 amperes (Column 10, Table 20).

Feeder Circuit. The rating of the branch-circuit fuse for a 25-h.p. squirrel cage motor is 300 per cent of 32 amperes, or 96 amperes (Table 27); and for a 30-h.p. wound-rotor motor is 150 per cent of 39 amperes or 59 amperes (Table 27). The rating of a feeder fuse is, therefore, 96 + 39 + 39 = 174 amperes, and a 175-ampere fuse is the maximum size which may be used. (See Order 13–4362.)

The setting of a motor-branch-circuit circuit-breaker for a 25-h.p. squirrel cage motor is 250 per cent of 32 amperes or 80 amperes (Table 27); for a 30-h.p. wound-rotor motor is 150 per cent of 39 amperes or 59 amperes (Table 27). The maximum setting of a feeder circuit-breaker is 80 + 39 + 39 = 158 amperes. (See Order 13–4362.)

PART 5

RADIO INSTALLATIONS

Orders formerly contained in this part of the code will be found in Section 13–810.

PART 6

PROTECTION OF BUILDINGS AND STRUCTURES AGAINST LIGHTNING

For complete codes on lightning protection see the following:

1. Code for Protection Against Lightning, National Bureau of Standards, Handbook H–21.

2. Code for Protection Against Lightning published by the National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts.

SECTION 160. SCOPE, DEFINITIONS, ETC.

Order 1600. Scope and Purpose.

The rules of this part of the code apply to the protection against lightning of buildings and other property, with the exception of property devoted to the production, storage, and transportation of flammable liquids and gases, and electric lines and equipment.

The purpose is the prevention of fire loss and other damages from lightning by directing attention to the available means of protection which are believed to be effective.

Order 1601. Interpretation and Exceptions.

This code shall be liberally construed. In cases of practical difficulty or unnecessary hardships exceptions from its literal requirements may be made if equivalent protection is otherwise secured.

It is not intended that this code shall be interpreted as recommending the protection of every class of property to which it applies, but shall constitute the standard where economic or other considerations make it appear that protection is necessary or desirable.

Order 1602. Mandatory and Advisory Requirements.

The word "shall" where used is to be understood as mandatory and the word "should" as advisory. "May" is used in the permissive sense.

Order 1603. Terms and Definitions.

Air Terminal: The combination of elevation rod, and brace, or footing placed on upper portions of structures, together with tip or point if used.

Conductor: The portion of a protective system designed to carry the current of a lightning discharge from air terminal to ground.

Branch Conductor: A conductor which branches off at an angle from a continuous run of conductor.

Cable: A number of wires twisted or braided to form a conductor.

Copper-Clad Steel: Steel with a coating of copper welded to it as distinguished from copper-plated or copper-sheathed material.

Down Conductor: The vertical portion of a run of conductor which ends at the ground.

Elevation Rod: The vertical portion of conductor in an air terminal by means of which it is elevated above the object to be protected.

Fastener: A device used to secure the conductor to the building.

Ground Connections: A buried body of metal with its surrounding soil and a connecting conductor which together serve to bring an object into electrical continuity with the earth.

Metal-Clad Building: A building with sides made of or covered with metal.

Metal-Roofed Building: A building with a roof made of or covered with metal.

Point: The pointed piece of metal used at the upper end of the elevation rod to receive a lightning discharge.

Roof Conductor: The portion of the conductor above the eaves running along the ridge, parapet, or other portion of the roof.

SECTION 161. LIGHTNING RODS FOR ORDINARY BUILDINGS

Orders 1610 to 1613, inclusive, hereunder apply more particularly to buildings of the ordinary types which have roofs of slate, tile or other non-conducting material. Order 1614 sets forth modifications to the orders preceding it which may be made for the case of buildings which are roofed, or roofed and clad with metal. Grounding and interconnection of metals are included in Orders 1615 to 1617 while Section 162 is to be referred to when buildings are equipped with spires, steeples, flag poles or towers.

Order 1610. Conductors.

A. *Materials.* The materials of which protective systems are made shall be relatively resistant to corrosion or shall be acceptably protected against corrosion. No combination of materials shall be used that forms an electrolytic couple of such nature that in the presence of moisture corrosion is accelerated, but where moisture is permanently excluded from the junction of such metals contact between them is not objectionable.

The following list of materials comprises those commonly used for protective systems, or parts of protective systems, and with their

accompanying specifications constitute materials to be regarded as standard for the purposes of this section.

1. Copper. Where copper is used it shall be of the grade ordinarily required for commercial electrical work, generally designated as being of 98 per cent conductivity when annealed.

2. Alloys. Where alloys of metals are used they shall be substantially as resistant to corrosion as copper under similar conditions.

3. Copper-clad steel. Where copper-clad steel is used, the copper covering shall be permanently and effectively welded to the steel core, and the proportion of copper shall be such that the conductance is not less than 30 per cent of the conductance of an equivalent cross-section of solid copper.

4. Galvanized steel. Where steel is used it shall be thoroughly protected against corrosion by a zinc coating which will satisfactorily withstand the standard test of the American Society for Testing Materials for galvanized coatings.

B. *Form and Size.* Branch and main conductors may be in the form of cable, tube, strip or rod having round, square, star or other cross-section. The following subsections give minimum sizes and weights.

1. Copper Cable. Copper cable conductors shall weigh not less than 187.5 pounds per thousand feet. The size of any wire of a cable shall be not less than No. 17 A. W. G. (0.045 inch).

2. Copper tube, copper solid section and copper-clad steel. Tube, or solid section conductors of copper or copper-clad steel shall weigh not less than 187.5 pounds per thousand feet. The thickness of any tube wall shall be not less than No. 20 A. W. G. The thickness of any copper ribbon or strip shall be not less than No. 16 A. W. G. (0.051 inch).

3. Galvanized steel. Galvanized steel conductors shall have a net weight of steel of not less than 320 pounds per thousand feet and a zinc coating of not less than 2 ounces per square foot of galvanized surface. The thickness of any tube wall, web or ribbon before galvanizing shall be not less than No. 17 U. S. Standard Sheet Gauge (0.056 inch) and the diameter of any wire of a cable before galvanizing shall be not less than No. 14 Steel Wire Gauge (0.080 inch).

C. *Joints.* 1. General. Joints in conductors shall be as few in number as practicable and where they are necessary they shall be mechanically strong and well made and provide ample electrical contact. The latter requirement is to be regarded as met by a contact area not less than double the conducting cross-sectional area of the conductor.

2. Mechanical strength. On structures exceeding 60 feet in height, joints shall be so constructed that their mechanical strength in tension as shown by laboratory tests is not less than 50 per cent of that of the smallest of the several sections of conductor which are joined together.

3. Electrical resistance. Joints shall be so made that they have an electrical resistance not in excess of that of two feet of conductor.

D. *Fasteners.* Conductors shall be securely attached to the building or other object upon which they are placed. Fasteners in general shall be substantial in construction, not subject to breakage and shall be, with the nails, screws, or other means by which they are fixed, of the same material as the conductor, or, of such nature that there will be no serious tendency towards electrolytic corrosion in the presence of moisture because of contact between the different parts.

Fasteners shall be so spaced as to give adequate support to the conductor, generally not over four feet apart.

Order 1611. Points and Elevation Rods.

A. *Attachment of Points.* Separate points are not required, but if used shall be of substantial construction and be securely attached to the elevation rods by screw or slip joints. The conducting cross-sectional area of the base shall be at least equivalent to the conducting cross-sectional area of the elevation rod.

B. *Elevation Rods.* 1. Size. Elevation rods shall be at least equivalent in weight and stiffness of a copper tube having an outside diameter of ⅝ inch and a wall thickness of No. 20 A. W. G. (0.032 inch).

2. Form. Elevation rods may be of any form of solid or tubular cross-section.

3. Height. The height of an elevation rod shall be such as to bring the tip not less than ten inches above the object to be protected. On flat or gently sloping surfaces a greater height than ten inches should be provided but the height need not exceed five feet.

C. *Braces for Elevation Rods.* 1. Use. Elevation rods shall be amply secured against overturning either by attachment to the object to be protected or by means of substantial tripod or other braces which shall be permanently and rigidly attached to the building.

2. Materials. The material from which braces are constructed shall be at least the equivalent in strength and stiffness of one-fourth inch round iron, and with the nails or screws used in erecting must comply with the requirements of "Order 1610 A Materials" as to resistance to corrosion or protection against corrosion.

3. Form and construction. Braces shall be assembled by means of riveted joints or other joints of equivalent strength. Preference should be given to tripod or fourlegged braces and when in place the feet should be spread until the distance between them approximates one-third the height of the brace.

4. Guides. Where elevation rods are more than 24 inches high, braces shall have guides for holding the elevation rod at two points located approximately as follows: The lower at a distance above the foot of the rod equal to one-third of its height, the upper at a distance above the lower equal to one-fourth the height of the rod.

Where elevation rods are 24 inches high or less, braces with a single guide may be used, holding the rod approximately midway of its height. Ten-inch elevation rods may be braced by means of substantial footings.

Order 1612. Prevention of Deterioration.

A. *General.* Precaution shall be taken in every instance to provide against any undue tendency toward deterioration due to local conditions.

B. *Corrosion.* Where any part of a protective system is exposed to the direct action of chimney gases or other corrosive gases, it shall be protected by a continuous covering of lead one-sixteenth inch or more in thickness.

C. *Mechanical Injury.* Where any part of a protective sytsem is exposed to mechanical injury it shall be protected by covering it with molding or tubing preferably made of wood or non-magnetic material. If metal tubing is used the conductor shall be electrically connected to it at its upper end.

D. *Use of Ornaments.* The use of small ornaments such as glass balls attached to elevation rods is not objectionable but elevation rods shall not be made to support vanes or ornaments having in any plane a wind resistance area in excess of 20 square inches.

Order 1613. Air Terminal and Conductors.

A. *General.* Air terminals shall be provided for all structural parts that are likely to receive, and be damaged by, a stroke of lightning.

B. *Projections.* In the case of projections such as gables, chimneys, and ventilators, the air terminal shall be placed on, or attached to, the object to be protected where practicable, otherwise within two feet of it.

C. *Ridges, Parapets, and Edges of Flat Roofs.* Along ridges, parapets, and edges of flat roofs, air terminals shall be spaced at intervals not exceeding 25 feet.

D. *Metal Projections and Parts of Buildings.* Metal projections and parts of buildings such as chimneys, ventilators, flagpoles, towers, water tanks, spires, smoke stacks, steeples, deck railings, shaft houses, gables, skylights, dormers, ridges, and parapets which are made of or covered with metal that are likely to receive, but not be appreciably damaged by, a stroke of lightning, need not be provided with air terminals, but shall be securely bonded to the lightning conductor with metal of the same weight per unit length as the main conductor.

E. *Coursing of Conductors.* Conductors shall in general be coursed over the roofs and down the corners and sides of buildings in such a way as to constitute as nearly as local conditions will permit, an enclosing network.

F. *Roof Conductors.* Roof conductors shall be coursed along contours, such as ridges, parapets, and edges of flat roofs, and where necessary over flat surfaces, in such a way as to join each air terminal to all the rest.

Roof conductors surrounding decks, flat surfaces, and flat roofs, shall be connected to form a closed loop.

G. *Down Conductors.* Down conductors shall preferably be coursed over the extreme outer portions of buildings, such as corners, due consideration being given to the best places for making ground connections, and to the location of air terminals.

H. *Obstructions.* Conductors shall be coursed around chimneys, ventilators, and similar obstructions in a horizontal direction.

I. *Bends.* No bend in a conductor which embraces a portion of a building such as an eave, shall have a radius of less than eight inches. The angle of any turn shall not exceed 90° and conductors shall everywhere preserve a downward or approximately horizontal course.

Order 1614. Metal-Roofed and Metal-Clad Buildings.

The materials and equipment required by this rule for the protection of metal-roofed or metal-roofed and clad buildings, shall comply with the requirements of Orders 1610 to 1613, inclusive.

A. *Metal in Overlapping Sections.* Buildings which are roofed, or roofed and clad, with metal in the form of sections insulated from one another, or so applied that they are not in electric contact, shall be treated in the same manner as are buildings composed of non-conducting materials.

B. *Metal Continuous.* When buildings are roofed or roofed-and-clad, with all metal sheets made electrically continuous by means of an interlocking or other contact, or by bonding, the following modifications may be made to the requirements of Orders 1611 to 1617, inclusive.

Air terminals need be provided only on chimneys, ventilators, gables, and other projections, such as are likely to receive and be damaged by a stroke of lightning. Projections that are likely to receive, but not be damaged by a stroke of lightning need not be provided with air terminals, but shall be securely bonded to the roof.

Roof conductors may be dispensed with, and elevation rods if used connected to the roof by soldered joints, or securely bolted joints, having an area of contact of not less than three square inches. If the roof metal is in small sections connection shall be made to at least four of the sections.

Down conductors shall be connected to the edges of roofs, or to the lower edges of metal siding, by soldered or bolted joints having an area of contact of at least three square inches. If the metal is in small sections. connection shall be made to at least four of the sections.

Order 1615. Number of Down Conductors.

A. *Minimum.* There shall be not less than two down conductors on any type of buildings, and these shall be run so as to be as widely separated as practicable. The following rules shall apply as to additional down conductors.

B. *Rectangular Structures.* On rectangular structures having gable, hip, or gambrel roofs, and exceeding 110 feet in length, there shall be at least one additional down conductor for each additional 50 feet of length, or fraction thereof.

On rectangular structures having French, flat, or sawtooth roofs, and exceeding three hundred feet in perimeter, there shall be at least

one additional down conductor for each additional 100 feet of perimeter or fraction thereof.

C. *Irregular-shaped Structures.* On an ell or T-shaped structure there shall be at least one additional down conductor; on an H-shaped structure at least two additional down conductors; and on a wing-built structure at least one additional down conductor for each wing.

On irregular-shaped structures the total number of down conductors shall in every case be sufficient to make the average distance between them along the perimeter not greater than 100 feet.

D. *Structures Exceeding 60 Feet in Height.* On structures exceeding 60 feet in height there shall be at least one additional down conductor for each additional 60 feet of height, or fraction thereof, except that the application of this rule shall not cause down conductors to be placed about the perimeter of a structure at intervals of less than 50 feet.

E. *Metal-Roofed and Metal-Clad Buildings.* The number of down conductors and ground connections for metal-roofed and metal-clad buildings shall be determined in the same manner as for buildings composed of non-conducting materials, i.e. according to the requirements of A, B, C, and D above.

F. *Dead Ends.* Additional down conductors shall be installed where necessary to avoid "dead ends," or branch conductors ending at air terminals, which exceed 16 feet in length, except that single down conductors descending flagpoles, spires, and similar structures which are adjuncts of buildings shall not be regarded as "dead ends" but shall be treated as air terminals.

Order 1616. Interconnection of Metallic Masses.

A. *Exterior Bodies of Metal.* Metal situated wholly on the exterior of buildings such as ornamental ridges, ventilators, roofs, valleys, gutters, down spouts, structural iron, etc., shall be connected to the conductor at its upper or nearest end, and if of considerable length, shall be grounded or electrically connected to the conductor at its lower or farthest end.

B. *Interior Bodies of Metal.* Metal situated wholly in the interior of buildings which at any point comes within 6 feet of a lightning conductor, or metal connected thereto, shall be electrically interconnected with it and, if of considerable size or length, shall be grounded at its lower or farther extremity within the building.

C. *Metal Bodies Projecting Through Sides and Roofs.* Metal which projects through roofs, or through sides of buildings above the second floor, shall be bonded to the nearest conductor at the point where it emerges from the building and be grounded at its lower or extreme end within the building.

D. *Interconnection of Metals on or within Metal-Roofed and Metal-Clad Buildings.* All parts of metal roofs, or roofs and sides, shall be securely bonded together.

E. *Metallic Bodies to be Independently Grounded.* Metallic bodies having any dimension exceeding five feet, and situated wholly within buildings, and which do not at any point come within six feet of a lightning conductor or metal connected thereto shall be independently grounded.

F. *Substitution for Regular Conductors.* Extended metal parts of buildings shall not be substituted for regular conductors, except where they are permanently electrically continuous, and have a conducting cross-sectional area at least double that of the lightning conductor that would otherwise be used.

G. *Size of Interconnecting and Bonding Wires.* For bonding, interconnecting and independent grounding of metallic masses the conductor used shall be at least the equivalent in strength and conducting cross-sectional area of a No. 6 A. W. G. copper wire, except where full size lightning conductor is required by Order 1613 D.

Order 1617. Ground Connections.

A. *Number.* A ground connection shall be provided for each down conductor, preference being given to metal water pipes connected to an extensive water system and other large underground metallic structures.

B. *Distribution.* Ground connections (and down conductors) shall be placed at as uniform intervals about a building as practicable, and grouping of ground connections on one side of the building shall be avoided.

C. *Moisture.* In making ground connections advantage should be taken of all permanently moist places where practicable, although such places should be avoided if wet with waste water which contains chemical substances especially corrosive to the metal with which the ground connection is made.

D. *Permanency.* Ground connections shall in every case be thoroughly and permanently made, with due regard to the character of the surrounding soil.

E. *Water-Pipe Grounds.* Where a water pipe enters a building at least one down conductor shall be connected to it preferably at a point immediately outside the foundation wall by means of a substantial clamp to which the conductor can be attached by bolts or solder. If the water system is limited in extent it shall be grounded to two made electrodes of the type described in Section 13–250. Any other limited Underground metallic system is to be grounded with two made electrodes.

F. *Grounding Electrodes in Deep Soil.* Where the soil is moist clay, or other soil of similar character as to electrical resistivity, artificial grounding electrodes may be made by extending the rod itself into the ground a distance of not less than 10 feet. Where the soil is largely sand, gravel, or stones, more extensive artificial grounding electrodes shall be made by adding metal in the form of driven rods or pipes, or strips, plates, or lengths of conductor buried in trenches as in "G" following.

G. *Grounding Electrodes in Shallow Soil.* Where bed rock is near the surface, ground connections may be made by digging trenches

radially from the building and burying in them the lowest ends of the down conductors or their equivalent in the form of metal strips or wires. Where the soil is very dry or will not permit digging to a depth of more than one foot in addition to the conductors laid radially, a similar conductor shall be buried which encircles the structure to be protected and connects all of the down conductors together.

H. *Trenches.* Trenches shall be long enough to accommodate 12 feet of conductor when laid straight, but need not be more than three feet in depth.

Order 1618. Radio Installations and Wires Entering Buildings.

A. *Metal Radio Masts on Buildings.* Metal radio masts on buildings shall be bonded to the nearest lightning conductor.

B. *Wooden Radio Masts.* Wooden radio masts which extend more than six feet above the ridge or highest parts of the buildings on which they are placed shall be treated in the same manner as flagpoles.

SECTION 162. MISCELLANEOUS STRUCTURES

Order 1620. Spires, Steeples, and Flag Poles.

A. *General.* The materials, equipment and ground connections required by the rules of this section for the protection of spires, steeples, and flag poles, shall comply with the requirements of Section 161.

B. *Air Terminals.* A single air terminal may be used, which elevates the tip a distance of not less than ten inches above the uppermost point of the structure.

C. *Down Conductors.* A single down conductor may be used, which, if the structure is isolated, shall be extended directly to a ground connection. If the structure is an adjunct of a building and near or touching the perimeter, the down conductor shall be extended directly to a ground connection, but shall also be connected to the lightning conductor system on the building. If it is set well within the perimeter the descending conductor shall be connected to the nearest roof conductor.

D. *Interconnection of Metals.* Bells, clocks, structural iron, and other metallic masses shall be connected to the down conductor. If the length of a metallic body is comparable to the height of the structure, connection shall be made at the upper and lower extremities; otherwise connection may be made at the nearest point.

E. *Grounding of Metallic Spires and Flagpoles.* Spires and flag poles composed entirely of or covered entirely with metal and resting on foundations of non-conducting material with the top so constructed as to receive a stroke of lightning without appreciable damage, need not be provided with air terminals or down conductors, but shall be grounded or connected to the nearest lightning conductor, or both, according as the structure is isolated, set within the perimeter of a building or near it, respectively.

Order 1621. Water Towers, Silos, and Similar Structures.

A. *General.* The materials, equipment and ground connections required by the rules of this section for the protection of water towers, silos, and similar structures, shall comply with the requirements of Section 161.

B. *Air Terminals.* The number and location of air terminals shall in general comply with the requirements of Order 1613, except that on silos and other towers having roofs ending in a peak a single air terminal may be regarded as sufficient.

C. *Conductors.* Where more than one air terminal is used they shall be connected together by a conductor which forms a closed loop about the structure near the top, or passes over it, as the contour of the roof may require. From this, or from the single air terminal if but one is used, at least two down conductors shall be extended directly to ground connections on opposite sides, if the structure is isolated. If it is an adjunct of a building, near or touching the perimeter, one down conductor shall be extended directly to a ground connection while the other may be connected to the lightning conductor system on the building. If it is set well within the perimeter both down conductors may be connected to the lightning conductor system on the building. If the height of the structure exceeds 100 feet the down conductors should be cross-connected midway between top and bottom.

D. *Interconnection of Metals.* All metallic bodies of considerable size or extent, whether exterior or interior, shall be connected to the down conductors. If their length is comparable to the height of the structure, they shall be connected to the down conductors at both ends; otherwise connection may be made at the nearest point.

E. *Grounding of Metal Towers and Water Tanks.* Towers and tanks composed entirely of or covered entirely with metal and resting on foundations of non-conducting material, with the uppermost portion so constructed as to receive a stroke of lightning without appreciable damage, shall be grounded by means of two earth terminals on opposite sides of the structure.

SECTION 163. BUILDINGS CONTAINING BALED FLAMMABLE MATERIALS

Order 1630. Methods and Materials.

The materials, equipment and ground connections required by the rules of this section shall comply with the requirements of Sections 161 and 162.

Order 1631. Metal-Roofed and Metal-Clad Buildings.

Metal-roofed and metal-clad buildings shall be treated in the same manner as required in Section 161, Order 1614.

Order 1632. Buildings of Non-Conducting Materials.

The effect of an electrostatic shield may be obtained by constructing on or above the roof a network of wires or cables and grounding it about the perimeter at the same intervals as required for metal-roofed buildings.

SECTION 164. SMOKESTACKS AND CHIMNEYS

Order 1640. Metal Smokestacks.

Metal smokestacks shall be properly grounded. If the construction of the foundation is not such as to provide ample electrical connection with the earth, ground connections shall be provided similar to those required for stacks made of materials other than metal as provided in Order 1641 G.

Metal guy wires and cables shall be grounded at their lower ends.

Order1641. Brick, Hollow Tile, and Concrete Stacks.

Where stacks of brick, hollow tile, concrete, or other material liable to damage by lightning are to be protected the following rules shall apply.

A. *Conductors.* Conductors shall be of copper of the grade required for commercial electrical work, generally designated as having 98 per cent conductivity when annealed.

The weight of the conductor shall be not less than 375 pounds per thousand feet.

The size of any wire in a cable shall be not less than No. 15 A. W. G. (0.057 inch).

The thickness of any tube wall shall be not less than No. 15 A. W. G. (0.057 inch).

The thickness of any web or ribbon shall be not less than No. 12 A. W. G. (0.080 inch).

B. *Fasteners.* Fasteners shall be of copper or copper alloy substantially as resistant to corrosion as the conductor itself, and must be strongly constructed. Each fastener must have a sufficiently tight grip to support its corresponding length of conductor.

Fasteners shall be spaced close enough to give ample support to the conductor, generally not over four feet apart.

C. *Air Terminals.* Air terminals shall be strongly constructed of the same grade of material as the conductor and shall be uniformly distributed about the rim of the stack at intervals not exceeding eight feet.

The height above the rim shall be not less than 30 inches.

They shall be secured to the top of the stack by means of expansion bolts or fan shank fasteners of substantial construction. The air terminals shall be electrically connected together by means of a metal ring or band which forms a closed loop about two feet below the top of the chimney. If there is a metal crown the air terminals should be connected thereto.

D. *Down Conductors.* At least two down conductors shall be provided on opposite sides of the stack, leading from the ring or crown at the top to the ground.

On stacks exceeding 160 feet in height the down conductor shall be cross-connected approximately midway between top and bottom. Where a metal ladder is continuous from the rim to the ground, and the vertical members have a combined cross-section not less than twice that specified in Order 1610 B, 3, such members may be utilized as down conductors.

E. *Lead Covering.* In order to prevent corrosion by gases, air terminals, conductors, and fasteners within 25 feet of the top of the stack should have a continuous covering of lead at least one sixteenth inch thick.

F. *Joints.* Joints in conductors must be as few as practicable and of such construction as to show by laboratory tests a strength in tension of at least 50 per cent of that of the conductor.

G. *Ground Connections.* Ground connections may be made in the manner prescribed for buildings in Order 1617.

H. *Protection Against Mechanical Injury.* Down conductors near the ground shall be protected against mechanical injury by means of wood molding or other non-magnetic material.

If metal tubing is used for protective purposes the down conductor shall be electrically connected to it at its upper end.

I. *Metal Linings.* Where stacks have a metal lining extending part way up the lining shall be connected to the rod at its upper end and grounded at the bottom.

SECTION 165. LIVESTOCK IN FIELDS

The information on this subject is limited, but the best obtainable has been made use of in formulating the following rules. On account of the nature of the exposure it is not possible, of course, to eliminate the hazard entirely, but it is believed that if these rules are applied it can be much reduced.

The loss of livestock by lightning is caused in large measure by herds drifting against ungrounded wire fences during thunderstorms and receiving a sufficient discharge to kill them, either from accumulated static electricity or from a stroke on the fence itself. The fences that give rise to the most trouble of this kind are those constructed with posts of poorly conducting material, such as wood or concrete. Fences built with metal posts set in earth are as safe from lightning as it is possible to make them, especially if the electrical continuity is broken as provided hereafter. Breaking the electrical continuity is very useful in that it prevents a lightning stroke from affecting the entire length of a fence, as it may if the stroke is direct and the fence continuous, even though grounded.

Isolated trees in pastures where stock congregate seeking shade are also a source of loss. In pastures where shade is available from wooded

areas of considerable size, isolated trees should be removed, but otherwise should be protected by suitable rodding as described in Order 1652 below.

Order 1650. Grounding of Wire Fences.

Where it appears desirable or necessary to mitigate the danger from wire fences constructed with posts of nonconducting material the following rules shall apply.

A. *Iron Posts.* Ground connections may be made by inserting at intervals galvanized-iron posts, such as are ordinarily used for farm fencing, and attaching in electrical contact all of the wires of the fence. If the ground is normally dry the intervals between metal posts shall not exceed 150 feet. If the ground is normally damp they may be placed 300 feet apart.

B. *Iron Pipe.* A less expensive ground connection than A, may be made by driving a length of one-half or three-quarter inch internal diameter galvanized iron pipe beside the fence and attaching the wires by ties of galvanized iron wire. The spacing shall be the same as for the posts under A above.

C. *Depth of Grounds.* Pipes or posts shall be extended into the ground at least three feet.

Order 1651. Breaking Continuity of Fence.

In addition to grounding the fence its electrical continuity shall be broken by inserting insulating material in breaks in the wires at intervals of about 1000 feet. These insertions may be in the form of fence panels of wood or lengths of insulating material to the ends of which the wires can be attached. Such lengths of insulating material may consist of strips of wood 2 x 2 x 24 inches, or their equivalent as far as insulating properties and mechanical strength are concerned.

Order 1652. Trees.

Where a tree is isolated and the vicinity is much frequented by livestock, the danger from lightning can be reduced by installing a single conductor extending from the top of the tree, to a distance of at least six feet into the ground.

Note: For protection of hangars, balloons, airships, ships, trees, and structures containing flammable liquids and gases, reference should be made to "Code for Protection Against Lightning," National Bureau of Standards Handbook H–21.

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