WISCONSIN STATE ELECTRICAL CODE

Fourth Edition

Effective October 15, 1934

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Industrial Commission of Wisconsin
and
Public Service Commission of Wisconsin

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Wisconsin State Electrical Code

Minimum fire and safety requirements for the construction and installation of all electrical, communication, signal, radio and lightning rod equipment; and rules to be observed in the operation of electrical equipment and lines.

FOURTH EDITION

Effective October 15, 1934

Madison, Wisconsin

BEFORE THE

PUBLIC SERVICE COMMISSION OF WISCONSIN

[U.—2776]

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.

WHEREAS, An investigation has been conducted by the Engineering Department of the Public Service Commission jointly with the Industrial Commission, 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 proper and reasonable notice of the hearing held in connection with the aforesaid investigation, and

WHEREAS, As a result of such hearing and 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 1699, inclusive, effective October 15, 1934.

IT IS THEREFORE ORDERED, That all railroads and public utilities subject to the jurisdiction of this Commission and subject to the requirements of Section 196.74 be, and they 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, copy of which is hereto attached.

IT IS FURTHER ORDERED, That all railroads and public utilities subject to the jurisdiction of this Commission, be, and are hereby, required to submit to this Commission full information regarding the construction and location (with

map) of all lines to be built or rebuilt in the future and described as follows:

All construction projects in rural districts where grade A or B construction is required which involve joint use of poles by communication and/or signal circuits with supply circuits or conflicts between communication and/or signal circuits with supply lines.

Note (1): The above includes major communication lines in conflict or in joint use with open wire supply lines above 5000 volts. Also minor communication lines in conflict or on the same poles with open wire supply circuits above 7500 volts. See definition of communication lines in Order 1020.

Note (2): The full information called for above shall include a statement that all utilities, individuals and railroads known to be involved or affected by the construction or changes have been notified.

This order will supersede and take the place of the order of this Commission with reference to standards for the safe construction and operation of electric systems, decided November 21, 1930.

Dated at Madison, Wisconsin, this 15th day of October, 1934.

PUBLIC SERVICE COMMISSION OF WISCONSIN,

A. R. McDONALD,
F. S. HUNT,
Commissioners.

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WISCONSIN STATE ELECTRICAL CODE

INTRODUCTION

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 third edition of the code became effective November 21, 1930 and a supplement to this edition was issued July 15, 1933. Later it became apparent that further revisions in the electrical code were necessary. The following committee representing the organizations noted, together with the advisers given below, met with representatives of the Industrial and Public Service Commission at various times during 1934.

ADVISORY COMMITTEE

C. B. Hayden, Madison, Chairman of Committee, Public Service Commission of Wisconsin
John E. Wise, Madison, Secretary of Committee, Industrial Commission of Wisconsin
Dr. M. G. Lloyd, Washington, D. C., U. S. Bureau of Standards
E. J. Kallevang, Madison, Wisconsin Utilities Association
Frank R. Daniel, Milwaukee, Fire Insurance Rating Bureau
F. H. Runkel, Madison, State Telephone Association
W. C. Lallier, Milwaukee, Wisconsin Telephone Company
T. E. Barnum, Milwaukee, Electrical Utilization Equipment Manufacturers
L. A. Wood, Chicago, C. B. and Q. Railroad
Wm. A. Haig, Milwaukee, Milwaukee Building Inspection Department
J. E. Florin, Madison, Industrial Commission of Wisconsin
B. H. Barg, Milwaukee, Electrical Contractors and Dealers Association of Milwaukee
Chas. Thurber, Wisconsin Federation of Labor

George E. Cooper, West Allis, Wisconsin Manufacturers Association
G. H. Andrae, Milwaukee, Contractor, State Association of Electrical Contractors and Dealers

The persons consulted as technical advisers were as follows:

V. H. Tousley, Chicago, Electric Field Engineer, National Fire Protection Association
W. S. Wilder, Milwaukee, T. M. E. R. & L. Co.
C. T. Reisz, Chicago, Western Union Telegraph Co.
George Crowell, Milwaukee, Engineer, Wisconsin Telephone Company
W. E. Gundlach, Milwaukee, Engineer, T. M. E. R. & L. Co.
John Sargent, Green Bay, Engineer, Wisconsin Public Service Corporation
E. H. Herzberg, Milwaukee, Manager, Milwaukee Branch of the Electrical Contractors and Dealers Association
R. E. Purucker, Wisconsin Public Service Commission

The final formal hearing was held at Madison on August 28, 1934, at which time the committee made a report to the two commissions. After fully considering the committee's recommendations, the attached code was adopted by the Industrial Commission September 7, 1934. The official publication of this action of the Industrial Commission took place in the official state paper on September 15, 1934 and hence became effective thirty days later; namely, October 15, 1934. 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 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. A number of cities already require interior wiring to be done in conduit for a larger variety of buildings than this code does, and where such is the case the local regulation must be met. In other words, 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 } ss.
CITY OF_____ }

I, _____, do hereby certify that I am the duly appointed, qualified and acting electrical inspector of said City: that I have inspected the following described electric wiring installed by, _____ _____ on the premises occupied by _____, and located at No. _____,

_____ Street, in said City, 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 on 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.

* 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 1933	*Subject Matter*
Chapter 101	Creation and duties of Industrial Comm.
Chapter 102	Workmen's compensation act
Chapter 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 196.67	Transmission lines and warning signs
Section 196.74	Safety and Interference
Sections 343.17 and 343.33	Diversion of current
Section 343.724	Poles on private property
Section 343.43	Injury to property
Section 348.38	Injury to wires

OTHER INDUSTRIAL COMMISSION PUBLICATIONS

The following publications will be furnished on request by the Industrial Commission:

Flammable Liquids Code
Building Code (Issued and sold by Bureau of Purchases)
Elevator Code
Boiler Code*
Industrial Lighting Code*
School Lighting Code*
Refrigerator Code
Heating and Ventilating 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

ENFORCEMENT

To avoid duplication of inspection, the enforcement of this code has been divided between the Public Service Commission and Industrial Commission as follows:

The Public Service Commission will inspect the properties of public utilities, which, in the main are covered by Parts 1, 2 and 4. The Industrial Commission and local inspection departments will enforce Parts 3 and 6.

* Out of print being revised 1934.

INTRODUCTORY PART

GENERAL REQUIREMENTS, DEFINITIONS, GROUNDING METHODS

Order 1000. Scope of Code.

This code shall apply as minimum fire and safety requirements for the construction and installation of all electrical, communication, signal, radio and lightning rod equipment; and the operation of electrical equipment and lines.

SECTION 101. GENERAL REQUIREMENTS

Order 1010. Character of Construction, Maintenance and Operation.

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

Note: In all electrical work conductors, however well insulated, should be so installed that the possibility of a leakage from conductor to conductor, or between conductor and ground will be a minimum.

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 will be 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 code.

(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. Inspection and Repairs.

All construction shall be inspected from time to time, cleaned when necessary, and if defective shall be promptly repaired or permanently disconnected. (See also Orders 1211 and 1213)

Note: Repairs, additions and changes to electrical equipment and conductors should be made by properly qualified persons only.

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 or its authorized agents. 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 rules in full to all new installations, reconstructions, 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 rules, providing the existing construction is reasonably safe, (2) by bringing existing installations into conformity with these rules as far as may be directed by the Industrial Commission or Public Service Commission and within the time determined by them.

(C) *Penalties.* Section 102.09–5, h, i, j, and k of the 1929 Wisconsin Statutes require

"(h) Where injury is caused by the failure of the employer to comply with any statute of the state or any lawful order of the industrial commission, compensation and death benefits as provided in sections 102.03 to 102.34 inclusive, shall be increased fifteen per cent."

"(i) Where injury is caused by the willful failure of the employee to use safety devices where provided by the employer, or

"(j) Where injury results from the employee's willful failure to obey any reasonable rule adopted by the employer for the safety of the employee, or

"(k) Where injury results from the intoxication of the employee, the compensation and death benefit provided herein shall be reduced fifteen per cent."

(D) *Temporary Installations.* It will sometimes be necessary to modify or waive certain of the rules in case of temporary installations or installations which are shortly to be dismantled or reconstructed. Such temporary con-

struction 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 rule, subject to review by proper authority.

SECTION 102. DEFINITIONS OF SPECIAL TERMS

Order 1020. Definitions.

The following definitions give the meanings of some of the terms occurring in these orders; terms not defined will be understood to have their customary meanings:

(1) *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").

(2) *Administrative Authority* means the Industrial and/or the Public Service Commission.

(3) *Adjustable Speed Motor* means one in which the speed can be varied gradually over a considerable range, but when once adjusted remains practically unaffected by the load, such as shunt motors designed for a variation of field strength.

(4) *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.

(5) *Antenna Conflict* means that an antenna or its guy wire is at a higher level than a supply or communication conductor and approximately parallel thereto, provided the

breaking of the antenna or its support will be likely to result in contact between the antenna or guy wire and the supply or communication conductor.

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

(7) *Armored Cable* is flexible metallic tubing in which the conductors have been inserted in the process of manufacture.

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

(9) *Authority* (See administrative authority).

(10) *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.

(11) *Automatic Fire Door.* One which closes automatically by means of a device operated by heat.

(12) *Branch Circuit* means that portion of a wiring system extending beyond the final automatic overload protective device of the circuit.

Lighting branch circuits are circuits supplying energy to lighting outlets only.

Appliance branch circuits are circuits supplying energy either to permanently wired appliances or to attachment plug receptacles, that is, appliance or convenience outlets, or to a combination of permanently wired appliances and additional attachment plug outlets on the same circuit; such circuits to have no permanently connected lighting fixtures. (For Medium-Duty and Heavy-Duty appliance Branch Circuits See Order 1316.02)

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

(14) *Cabinet* means an inclosure designed either for surface or flush mounting, and provided with a frame, matt or trim in which swinging or sliding doors are placed. (see cutout box).

(15) *Cable* means a stranded conductor (single-conductor cable) or a combination of conductors insulated from one another (multiple-conductor cable).

(16) *Circuit* means in general a conductor, or system of conductors and connected equipment designed to carry an electric current.

(17) *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.

(18) *Climbing Space* means the vertical space reserved along the side of a pole or supporting structure to permit ready access for linemen to equipment and conductors located thereon.

(19) *Common Use* means simultaneous use by two or more utilities of the same kind.

(20) *Communication Lines* means the conductors and their supporting or containing structures which are located outside of buildings and are used for public or private signal or communication service and which operate at not exceeding 400 volts to ground or 750 volts between any two points of the circuit and the transmitted power of which does not exceed 150 watts. When operating at less than 150 volts no limit is placed on the capacity of the system.

Telephone, telegraph, messenger-call, clock, fire or police alarm, and other systems conforming with the above are included.

Lines used for signaling purposes, but not included under the above definition are considered as supply lines of the same voltage and are to be so run.

Exception is made under certain conditions for communication circuits used in the operation of supply lines. (See order 1288).

Communication lines carrying not more than two circuits used mainly for local telephone or telegraph service, or for police or fire alarm service are referred to as minor communication lines.

(21) *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.

(22) *Conductor* means a metallic conducting material, usually in the form of a wire or cable, suitable for carrying an electric current. In this code when conductors of the bus-bar type are referred to, they will always be designated as bus-bars.

(23) *Conductor Conflict* means that a conductor is so situated with respect to a conductor of another line at a lower level that the horizontal distance between them is less than the sum of the following values.

(a) Five feet, plus

(b) One-half the difference of level between the conductors concerned, plus

(c) The value required in Tables 6, 7 and 8 of Order 1235 for horizontal separation between conductors on the same support for the highest voltage carried by either conductor concerned.

(24) *Conduit* means a tube or duct especially constructed for the purpose of inclosing electrical conductors.

By rigid steel conduit is meant a tubular raceway with threaded ends, for electric wires and cables, having a corrosion resistant coating on all surfaces, except threads, and a uniformly smooth interior coating of enamel or like material, made of mild steel pipe of circular cross section, having walls which in the various electrical trade sizes comply with the measurements and weights set forth in Order 1305.03.

Flexible metallic conduit is 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.

(25) *Conflict.* (See definitions of Antenna, Conductor and Structure Conflicts.)

(26) *Controller* means a device or group of devices, which serve to govern, in some predetermined manner, electrical power delivered to the device governed.

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

(28) *Cutout Box* means an inclosure 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)

(29) *D. C. Neutral Grid.* A well grounded network of neutral conductors formed by connecting together within a given area all of the neutral conductors of a low-voltage direct current supply system.

(30) *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.

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

(32) *Disconnector–Disconnecting Switch* means a switch which is intended to open a circuit only after the load has been thrown off by some other means. (See Definition of Switch)

Note: Switches designed for opening loaded circuits are usually installed in circuits with disconnectors, to provide a safe means for opening the circuit under load. [See (58) Isolating Switch]

(33) *Diversity Factor* means the ratio of the sum of the maximum power demands of the subdivisions of the system, or part of a system, to the maximum demand of the whole system, or part of the system under consideration, measured at the point of supply.

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

(35) *Dust-tight* means so constructed that dust will not enter the inclosing case.

(36) *Electrical Metallic Tubing* is a thin-walled steel 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.

(37) *Electrical Supply Equipment* means equipment which produces, modifies, regulates, controls, or safeguards a supply of electrical energy. Similar equipment, however, is not included where used in connection with signaling systems under the following conditions:

(a) Where the voltage does not exceed 150.

(b) Where the voltage is between 150 and 400 and the power transmitted does not exceed 3 kilowatts. (See definition of Utilization Equipment)

(38) *Electrical Supply Lines* means those conductors and their necessary supporting or containing structures which are located entirely outside of buildings and are used for transmitting a supply of electrical energy. (See Definition of communication lines)

Railway signal lines of more than 400 volts to ground are always supply lines within the meaning of these rules, and those of less than 400 volts may be considered as supply lines, if so run and operated throughout.

Note: Does not include open wiring on buildings in yards or similar locations where spans are less than 20 feet and all the precautions required for stations or utilization equipment, as the case may be, are observed.

(39) *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)

(40) *Enclosed:* See inclosed.

(41) *Explosion-Proof.* Explosion-proof means inclosed 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 inclosure, by sparks, flashes or explosions of the specified gas or dust which may occur within the inclosure.

(42) (a) *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.

(b) *Exposed* (applied to equipment) means that an object or device can be inadvertently touched or approached nearer than a safe distance by any person. It is applied to objects not suitably guarded or isolated.

(43) *Externally Operable.* 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 inclosed in a case or a cabinet.)

(44) *Factory Yard* means a plot containing an assemblage of buildings served by an isloated plant, or by a substation, or by a master service, and permitting access from building to building within the yard.

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

(46) *Grounded System* means a system having a permanent and effective electrical connection to earth. This ground connection may be at one or more points.

Note: "Effective", as herein used, means a connection to earth of sufficiently low resistance and high current-carrying capacity to prevent any current in the ground wire from causing a harmful voltage to exist between the grounded conductors and neighboring exposed conducting surfaces which are in good contact with the earth, or with neighboring surfaces of the earth itself, under the most severe conditions which are liable to arise in practice.

(47) *Guarded* means covered, shielded, fenced, inclosed, or otherwise protected, by means of suitable covers, casings, barrier 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)

(48) *Handhole* means an opening in an underground system into which workmen reach but do not enter.

(49) *Household Appliances* means flatirons, washing machines, toasters, percolators, vibrators, heating pads and other portable current consuming devices intended for use in the home and similar places.

(50) *Hazardous Location* means premises, locations, rooms or portions thereof in which (1) highly flammable gases, flammable volatile liquids, mixtures or other highly flammable substances are manufactured or used or are stored in other than original containers; or (2) where combustible dust or flyings are likely to be present in quantities sufficient to produce an explosive or combustible mixture; or (3) where it is impracticable to prevent dust from collecting in such quantities on or in motors, lamps or other electrical devices that they are likely to become overheated because normal radiation is prevented; or (4) where easily ignitible fibres or materials producing combustible flyings are handled, manufactured, stored or used.

(51) *Hoistway* means a hoistway in any shaftway, hatchway, well-hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

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

(53) *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.

(54) *Insulation* (when applied to a material or device such as the covering of a conductor or to clothing, guards, rods, and other safety devices) means that the material or 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).

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

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

(57) *Isolated Plant.* A private electrical installation deriving energy from its own generator driven by a prime mover.

(58) *Isolating Switch.* A switch intended for isolating a circuit from its source of power. It is to be operated only when the circuit has been opened by some other means. (See (32)—Disconnector)

(59) *Joint Use* means simultaneous use by two or more kinds of utilities.

(60) *Lateral Conductor* means, in pole wiring work, a wire or cable extending in a general horizontal direction at an angle to the general direction of the line conductors. (See Definition of Vertical Conductor)

(61) *Lateral Working Space* means the space reserved for working between conductor levels outside the climbing space, and to its right and left.

(62) *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. (See Definition of Vertical Conductor)

(63) *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.

(64) *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.

(65) *Manhole.* (More accurately termed splicing chamber or cable vault) means an opening in an underground system which workmen or others may enter for the purpose

of installing cables, transformers, junction boxes, and other devices, and for making connections and tests.

(66) *Manual* means capable of being operated by personal intervention.

(67) *Master Service* means the service conductors supplying a group of buildings under one management.

(68) *Minor Communication Lines.* Lines carrying not more than two circuits used mainly for local telephone or telegraph service or for police or fire alarm service are referred to as minor communication lines.

(69) *Minor Tracks* means railway tracks included in the following list:

(a) Spurs less than 2,000 feet long and not exceeding two tracks in the same span.

(b) Branches on which no regular service is maintained or which are not operated during the winter season.

(c) Narrow-gauge tracks or other tracks on which standard rolling stock cannot, for physical reasons, be operated.

(d) Tracks used only temporarily for a period not exceeding one year.

(e) Tracks not operated as a public utility, such as industrial railways used in logging, mining, etc.

(70) *Motion Picture Studio.* Any building or portion of a building in which motion picture films are manufactured, developed, printed, rewound, repaired, stored or otherwise exposed.

(71) *Motor-Circuit Switch.* A switch intended for use in a motor-branch-circuit. It is rated in horsepower and is capable of interrupting the maximum operating overload current of a motor of the same horsepower rating at the rated voltage. The maximum operating overload current of A. C. motors is six times the rated current, and of D. C. motors is four times the rated current.

(72) *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 Equipment.)

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

(74) *Open Wires* means overhead wires not in conduits and consisting of single conductors or of individual twisted pairs, as opposed to multiple conductor cables.

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

(76) *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 overload 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).

(77) *Permanently Grounded* means such an effective connection to the earth (by means of an underground system of metallic pipe mains or other suitable means) as described in Definitions of Grounded and Grounded System.

(78) *Pole Face* means that side of a pole on which crossarms are attached, or which is so designated by the companies owning or operating the pole.

(79) *Portable Appliance* means small electrical apparatus such as grinders, drills, etc., which are supplied with current from a portable connection; apparatus which can be easily moved about or lifted and is intended to be so handled when in use; does not include household appliances as defined herein. (See movable equipment)

(80) *Qualified* means familiar with the construction and operation of the apparatus and the hazards involved. Responsibility for the decision as to the qualifications of the employes rests with the employer or his agent.

(81) *Raceway* means any channel for loosely holding wires or cables in interior work which is designed expressly and used solely for this purpose. Raceways may be of metal, wood (if specifically permitted) or insulating material. The term includes wooden and metal moldings consisting of a backing and capping and also metal ducts into which wires are to be pulled.

(82) *Rain-tight* means so constructed or protected that exposure to a beating rain will not result in the entrance of water.

(83) *Readily Accessible:* Capable of being reached quickly, for operation, renewal or inspection, without requiring those to whom ready access is requisite to climb

over or remove obstacles or to resort to portable ladders, chairs, etc.

(84) *Reconstruction* means rebuilding or remodeling an existing installation, but does not include ordinary maintenance replacements. (Reconstruction of a substantial portion of an installation is New Construction). (See Definition of New Construction)

(85) *Rural Districts* means all places not urban, usually in the country, but in some cases within city limits. (See Definition of Urban Districts)

(86) *Sag—Apparent sag of a span* means the departure of the wire in a given span from the straight line between the two points of support of the span at 60° F., with no wind loading. Where the two supports are at the same level this will be the normal sag.

(87) *Sag—Apparent sag at any point* means the maximum departure of the wire at the particular point in the span from the straight line between the two points of support of the span, at 60° F., with no wind loading.

(88) *Sag—Normal sag* means the difference in elevation between the highest point of support of a span and the lowest point of the conductor in the span (or in the curve of the conductor in the span produced) at 60° F., with no wind loading.

(89) *Sealable Equipment.* Equipment inclosed 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 inclosure. The equipment may or may not be operable without opening the inclosure.

(90) *Secondary Neutral Grid.* A well grounded network of neutral conductors formed by connecting together within a given area all the neutral conductors of individual transformers secondaries of the supply system.

(91) *Service.* A service is the conductors and equipment for delivering electrical energy from the main or feeder or from the transformer to the wiring system of a building.

(92) *Service Conductors.* That portion of the supply conductors which extends from the street main or duct or from transformers to the service equipment of the building supplied. For overhead conductors this includes the conductors from the last line pole to the service equipment.

(93) *Service Drop.* That portion of overhead service conductors between the pole and building and extending to the junction with the service entrance conductors.

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

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

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

(96) *Service Raceway.* The rigid steel conduit or electrical metallic tubing that incloses service entrance conductors.

(97) *Service Pipe.* The conduit or pipe that contains underground service conductors and extends from the junction with outside supply wires into the consumers premises.

(98) *Service Cable.* Service conductors made up in the form of cable.

(99) *Shall* is used to indicate requirements.

(100) *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.

(101) *Special Permission* means the written consent of the Industrial or Public Service Commission.

(102) *Structure Conflict* (as applied to a pole line) means that the line is so situated with respect to a second line that the overturning (at the ground line) of the first line will result in contact between its poles or conductors and the conductors of the second line, assuming that no conductors are broken in either line.

Exceptions: Lines are not considered as conflicting under the following conditions:

(1) Where one line crosses another.

(2) Where two lines are on opposite sides of a highway, street or alley and are separated by a distance not less than 60 per cent of the height of the taller pole and not less than 20 feet.

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

(104) *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.

(105) *Switchboard* (Supply Station Switchboard) means a large single panel, frame, or assembly of panels, on which are mounted, on the face or back or both, switches, overload and other protective devices, busses, 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.)

(106) *System Ground Conductor:* An auxiliary, well grounded conductor used for connecting together the individual grounding conductors throughout a given area, but which is not a part of a circuit wire.

(107) *Tags* means tags or other markers of distinctive appearance, indicating that men are at work on the equipment or lines so designated.

(108) *Totally Inclosed Motor.* A motor which is so completely enclosed by integral or auxiliary covers as to practically prevent the circulation of air through the interior. Such a motor is not necessarily air-tight.

(109) *Transformer vault* means an isolated, fireproof inclosure, either above or below ground, in which transformers, and the devices necessary for their operation, are installed and which is not continuously under attendance during operation.

(110) *Urban Districts* means thickly settled areas, whether inside city limits or not.

(111) *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. (See Definition of Electrical Supply Equipment.)

(112) *Vapor-tight:* So inclosed that vapor will not enter the inclosure.

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

(114) *Vertical Conductor* means, in pole wiring work, a wire or cable extending in an approximately vertical direction. (See Definitions of Lateral and Line Conductors.)

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

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

When one circuit is directly connected to another circuit of higher voltage (as in the case of an autotransformer) both are considered as of the higher voltage, unless the circuit of lower voltage is permanently grounded.

Note: Direct connection implies electrical connection as distinguished from connection merely through electromagnetic or electrostatic induction.

(116) *Voltage to Ground:* The voltage between the given conductor and that conductor of the circuit which is grounded; in ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

(117) *Waterproof* means so constructed or protected that moisture will not interfere with its successful operation.

(118) *Watertight:* So constructed that moisture will not enter the inclosing case.

(119) *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.

(120) *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.

SECTION 103. PROTECTIVE GROUNDING

Order 1030. Grounding, General.

(A) The following orders apply to where and how supply equipment, lines, wiring systems, equipment, arresters, cable armor, conduit, or other metal raceways, and the like shall be grounded when such grounding is intended as a

permanent and effective protective measure. Additional requirements and information will be found in the following orders:

Grounding supply equipment in supply stations	Order 1123
Grounding equipment during repairs	Order 1123C
Grounding machine frames in supply stations	Order 1132
Grounding instrument transformer circuits	Order 1151
Grounding transformer cases in stations	Order 1152
Grounding devices	Order 1173
Grounding noncurrent carrying parts of switches, etc.	Order 1177
Grounding switchboards	Order 1185
Ground for temporary grounds	Order 1185B
Grounding lightning arresters	Order 1193
Using ground as part of the circuit	Order 1215C
Grounding pins	Order 1276B 1278
Grounding of riser pipes	Order 1297B
Grounding communication circuits and equipment	Order 1360.05
Grounding lines	Order 1423F
Making protective grounds	Order 1424
Grounding metal supports on roofs	Order 1614
Radio ground connections	Sec. 133.7
Grounding of lightning rods	Order 1617

Additional references to other orders referring to grounding will be found in the orders which follow, for example, in Order 1033.

These orders do not apply to the grounded return of electric railways, nor to the grounding of lightning protection wires.

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

Order 1031. Grounding Electric Systems.

(A) *Direct Current.* (1) Two wire direct-current systems supplying interior wiring systems and operating at not to exceed 300 volts between conductors shall be grounded on one conductor at the supply station but not at individual services or elsewhere on the interior systems.

It is recommended that such 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.

(2) Three-wire direct-current systems supplying interior wiring systems shall be grounded on the neutral at one or more supply stations but not at individual services or elsewhere on the interior systems.

(B) *Alternating Current.* (1) Secondary alternating distributing systems supplying wiring systems serving utilization equipment shall be grounded if they can be so grounded that the maximum voltage to ground does not exceed 300 volts.

(2) In alternating-current distribution systems ground connections shall be made at the building service by the customer and near the transformer (or transformers) by the utility either by direct ground connection through an extended water piping system or artificial ground (see Order 1035) or by the use of a system ground wire to which are connected the grounding conductors of many secondary mains, and which is itself effectually grounded at intervals that will fulfill for any secondary utilizing the system ground wire the resistance and current-carrying requirements of Order 1035F.

(a) In single-phase, three-wire systems the ground connection shall be made on the neutral conductor.

(b) In single-phase, two-wire systems the ground connection shall be made on the neutral point or on either conductor.

(c) In two-phase, three-wire systems, the ground connection shall be made to the conductor common to both phases. In two-phase, four-wire systems, a ground connection shall be made to the neutral point of each phase.

(d) In three-phase, three-wire, delta systems, the ground connection shall be made on one conductor or on the neutral point of one phase.

Note: Where the ground is made to the neutral point of one phase and the neutral not extended to a building service, two ground wires and two ground electrodes shall be placed at the pole with the transformer.

(e) Where one phase of a two or three phase system is used for lighting, that phase shall be grounded and at the neutral conductor, if one is used.

(f) In three-phase, three-wire or four-wire, star connected systems, the ground connections shall be made at the point common to all the phases.

(3) Interior wiring systems shall be grounded at the service entrance when such grounding results in voltages to ground not to exceed 300 volts.

(a) For an interior system not electrically connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard and on the supply side of the first switch controlling the system.

(b) In a property comprising more than one building under single management such as a farm or institution and served by a master switch, the interior wiring systems and the metal raceway system if used in the various buildings shall be grounded together at the entrance to the various buildings.

Note: See Sec. 130.5 for wiring method.

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

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

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

(d) The grounding connection for an interior wiring system shall be made at one point only within a building.

(e) Where transformers supply a common set of distribution mains, such fuses as are installed shall be so placed as not to leave any portion of the secondary system without grounding protection after the fuses have opened.

(f) Electric furnace circuits need not be grounded.

(g) In the absence of a direct ground connection at all building services, ground connections shall be made to the grounded neutral or other grounded conductor of a secondary system supplying more than one utilization equipment, at intervals that will fulfill the resistance and current carrying requirements of Order 1035.

Note: This is to take care of older installations without grounded services.

(C) Lightning Arresters and Ground Detectors. For lightning arresters and ground detectors the ground connection shall be at such a point that the grounding conductor is as short and straight as practicable, and free from sharp bends.

Order 1032. Grounding of Conduit and Other Metal Raceways or Inclosures.

Note: For special requirements in hazardous locations see Section 133.2. See Sec. 130.5.

(A) Metal conduit, cable armor, and other metal raceways or inclosures for wires, shall be grounded, whether the contained interior wiring system conductors are grounded or not, unless in runs of less than 25 feet which are free from contact with ground or grounded metal, and, where situated within reach from grounded surfaces, are guarded against contact by persons. See also 1350.02.

(B) Service raceways and service cable sheaths and/or armoring shall be grounded. Where there are meter cabinets or fittings interposed in the service run, the sections of raceway or sheath or armor shall, unless threaded connections are employed, be bonded together by means approved for the purpose. Service conduit or metal pipe from underground supply is considered to be grounded if it contains metal sheathed cable bonded to a continuous underground metal sheathed cable system. (See Order 1304.04j.) The sheath or armor of service cable from underground supply is considered to be grounded if it is metallically connected to a continuous underground metal sheathed cable system.

(C) Interior conduit, cable armor, and other metal raceways or inclosures for wires, shall be metallically joined together into a continuous electrical conductor. In wet locations metal boxes, cabinets, and all outlet and terminal fittings, shall be grounded. In dry locations, such boxes, etc.,

shall be grounded unless kept free from contact with foreign metal other than short runs of isolated conduit, etc., as provided in paragraph (A) of this Order. Metal boxes, cabinets and fittings, if metallically connected to grounded conduit or other metal raceway, are considered to be grounded by the connection to the raceway or armor.

Note: It is recommended that where knob and tube wiring or non-metallic sheathed cable is used, these boxes, etc., be kept clear of metal lathing by cutting away the metal lath for a sufficient distance around the box.

(D) Where a raceway system contains any conductor at more than 150 volts to ground, the electrical continuity of the system shall be assured by one of the following methods:

1. Approved threaded fittings with joints made up tight.
2. Approved threadless fittings, made up tight, including fittings for rigid conduit, electrical metallic tubing, armored cable, and flexible conduit.
3. Bonding jumpers of a size equal to that specified for the grounding conductor for interior conduit (See Order 1036) and with proper fittings.
4. Two locknuts, one inside and one outside of boxes or cabinets.
5. Other devices approved for the purpose.

In hazardous locations the locknut bushing and double-locknut type of contact shall not be depended upon for bonding metal boxes, cabinets, and the like, irrespective of the voltage of the circuits contained therein but bonding jumpers with approved fittings or other approved means shall be used. (See section 133.2)

Note: For service entrance conduit see Order 1032B.

(E) Isolated sections of conduit, cable armor, or other metal raceway, required in Order 1032(A) to be grounded, shall preferably be grounded by interconnecting to grounded conduit, cable armor, or other metal raceway, or when this is impracticable, by separate grounding connections.

Order 1033. Grounding of Fixed Equipment.

(A) Exposed non-current carrying metal parts of fixed equipment shall be grounded as follows:

Note: See Order 1030 for further references to the grounding of fixed equipment, etc.

(1) Metal inclosures for service equipment as provided in Order 1304.05j.

(2) Generators as provided in Order 1310.06a.
(3) Motors as provided in Order 1310.06b.
(4) Controller cases, as provided in Order 1310.06c.
(5) Switch and circuit-breaker inclosures with any wire operating over 150 volts to ground, as provided in Order 1312.02d.
(6) Switchboard frames, as provided in Order 1313.01e.
(7) Lighting fixtures, as provided in Order 1314.03.
(8) Arc lamps on circuits in excess of 150 volts to ground, as provided in Order 1315.02b.
(9) Mercury-vapor lamps where within easy reach from grounded surfaces, as provided in Order 1315.03b.
(10) Electrically heated appliances on circuits above 150 volts to ground as provided in Order 1316.06a.
(11) Resistors, reactors, and capacitors, as provided in 1317.01c.
(12) Lightning arresters as provided in 1319.01i.
(13) Tracks and frames of electric cranes, as provided in Order 1330.08a.
(14) Elevators, as provided in Order 1331.01d and Order 1331.04a to e inclusive.
(15) Equipment in hazardous locations, as provided in Orders 1332.03p, 1332.04o, 1332.05o, and 1332.06p.
(16) Equipment in garages, as provided in Order 1333.08a.
(17) Equipment in motion picture studios, as provided in Order 1334.02i.
(18) Motion picture projection equipment, as provided in Order 1335.01e.
(19) Equipment in theaters, as provided in Order 1336.14a.
(20) Signs and troughs for outline lighting, as provided in Order 1338.06a.
(21) Vacuum and inert-gas systems, as provided in Order 1338.08e.
(22) Organ equipment, as provided in Order 1339.02b.
(23) Apparatus operating at more than 600 volts, as provided in Order 1350.09b.
(24) Transformer and capacitor cases, except instrument transformers, as provided in Order 1311.02e and Order 1350.04c.
(25) X-ray apparatus, as provided in Order 1351.03a.
(26) All fixed equipment (unless suitably isolated) regardless of voltage, in continuously wet places.

(B) Non-current carrying parts of fixed equipment may be grounded by metallically connecting them to the grounded metal raceway or cable armor, or otherwise as provided in Order 1035. (See 1036J.)

(C) Instruments, meters, or relays which operate with windings or working parts at 300 volts or more to ground shall have the cases and other exposed bare metal parts grounded unless isolated by elevation or protected by suitable insulating barriers or guards. An exception is made where the equipment is inaccessible to other than qualified persons, in which case the above protection is not required up to and including 750 volts. Above 750 volts cases shall be isolated by elevation or protected by suitable barriers, grounded metal, or insulating covers or guards. Where instruments, meters, or relays are operated from current or potential instrument transformers on circuits of 300 volts or more to ground, having ungrounded secondary circuits and ungrounded primary circuits, the cases and other exposed bare metal parts shall be grounded. See Order 1036(Q). For exception see 1313.02g.

(D) Fixed non-current carrying parts on poles which are more than eight feet from the ground such as transformer cases may or may not be grounded depending on the company's rules. The company shall follow a standardized practice and make their operating rules conform to the practice adopted. If any portion of these non-current carrying parts are located within 8 feet of the ground they shall be grounded.

Order 1034. Grounding of Portable Equipment.

(A) Exposed non-current carrying metal parts of portable equipment shall be grounded as follows:

1. Portable motors which operate at more than 150 volts to ground, as provided in Order 1310.06b.

Note: It is recommended that the frames of portable motors which operate at less than 150 volts to ground be grounded when this can be readily accomplished.

2. Portable electrically heated appliances operating on circuits in excess of 150 volts to ground, as provided in Order 1316.06a.

3. Portable lamps or other portable current consuming appliances in hazardous locations as provided in Orders 1332.03p, 1332.04o, 1332.05o, and 1332.06p.

4. Portable apparatus operating at more than 600 volts, as provided in Order 1338.08e.

(B) The grounding of non-current carrying parts of portable equipment may be accomplished by metallically connecting such parts to the grounded metal raceway or cable armor of the circuit supplying the equipment or, otherwise as provided in Orders 1035A, 1035C, 1035D, 1036K.

Order 1035. Grounding Electrodes.

(A) *General.* The ground connection shall be permanent and effective and shall be made as indicated below, but circuits and equipment shall always be grounded where required to an extensive continuous metallic underground water piping systems if they are available.

Note: "Available" in this rule means ordinarily within 500 feet for stations. In interior wiring available means within the building served.

(B) *Piping Systems.* (1) In supply stations, ground connections for circuits and equipment shall be made to all available active extensive metallic underground water piping systems between which no appreciable difference of potential normally exists, and to one such system if appreciable differences of potential do exist between them.

(2) In other places circuit and equipment ground connections shall be made to at least one such system.

(3) Gas piping systems within buildings connected to continuous metallic underground exterior systems may be used as a ground electrode but only when a continuous water piping system is not available. Gas piping, however, may serve as the sole ground for small fixtures located at a considerable distance from water piping. Where gas piping on the house side of the meter is utilized for grounding small fixtures, it shall be bonded to the water piping system at their points of entrance and a bonding jumper shall be placed around the gas meter. If no water piping is available a bonding jumper around the gas meter shall be used. Where grounding connection is made to gas piping, except for such small fixtures, it shall follow the same requirements as for water-piping, except that the connection shall always be made on the street side of the meter. Gas piping need not be insulated from otherwise well-grounded fixtures.

(C) *Alternate Methods.* Where suitable extensive underground metallic piping systems are not available, one of the following methods may be employed:

1. The metal frame of the building when effectively grounded.

2. An artificial ground whose electrode consists of a driven pipe, driven rod, or buried plate.

3. An extended system ground wire which is properly grounded at a number of points.

(D) *Artificial Grounds.* When resort must be had to artificial grounds, the number of grounds shall be determined by the following requirements.

(1) No more than one such ground is required for lightning arresters, except where for large current capacity (See also Order 1037J).

(2) At least two grounds are required for low voltage alternating current distribution circuits, one at transformers or elsewhere on the secondary and one at each customer's service.

Exception: When an extended system ground wire is used the connection at the service entrance shall be made to the ground wire. Also see (3) below.

(3) Where no part of the circuit or equipment protected can be reached by persons while they are standing on the ground or damp floors, or by persons while touching any metallic piping to which the ground wire is not effectively connected, a single artificial ground may be used even if the resistance exceeds that specified in Order 1036F. In such cases the grounding conductor must be guarded according to Order 1036P.

(E) *Connections to be Avoided and Recommendations.* (1) No electric conductor or noncurrent carrying part of electric equipment shall be grounded to a small water system, small sewage system, wells, pump casings, small gas systems, gas tanks, or any small metallic systems, parts of which are at times in contact with persons or animals unless a permanently assured ground resistance of less than 3 ohms is obtained.

Note: It is advisable from a safety standpoint to keep lightning rod grounds free from such metallic structures as pumps, cow stanchions, etc. which are frequently in contact with persons or animals. It is advisable in installations such as farms that the pump motor be insulated from the water pump. (See Note under Sec. 130.5)

(2) The grounding conductors for circuits, conduit, equipment, and the like shall not be connected to lightning rod conductors.

Note: Such grounding conductors and lightning rods should be kept at least 6 feet apart.

(3) Grounds to Railway Returns. Rails or other grounded conductors of electric railway circuits shall not be used as a ground for other than railway lightning arrester and railway equipment, conduit, armored cable, metal raceway, and the like. 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 itself.

Note: This order does not prohibit the making of drainage connections (which are not protective grounds) between piping systems and railway return circuits for the prevention of electrolysis.

Where multiple artificial grounds are made on other circuits near such railway returns, they should be so arranged as to prevent the flow of any considerable current in and between such connections, thus reducing their effectiveness, or causing other damage.

(F) *Sizes, Number and Resistance of Ground Electrodes.* (1) The combined resistance of the grounding wire and the connection with the ground shall not exceed 3 ohms for water-pipe connections.

(2) Artificial grounds.

(a) Where artificial grounds, plates, or rods are used they shall as far as practicable, be embedded below permanent moisture level.

(b) Where buried plates are used they shall present not less than 2 square feet of surface to exterior soil. If such a plate does not produce or it is doubtful if it will produce a resistance to ground (grounding wire and connections included) of 25 ohms or less, a plate or plates shall be installed which will present not less than 4 square feet to the exterior soil. Electrodes of plate copper shall be at least .06 inch in thickness. Electrodes of iron or steel plates shall be at least ¼ inch in thickness.

(c) Electrodes of iron or steel pipe shall be galvanized and not less than ¾ inch internal diameter. Electrodes of rods of steel or iron shall be at least ¾ inch minimum cross section dimension. Approved rods of nonferrous materials or their approved equivalent used for electrodes shall be not less than ½ inch in diameter.

Driven electrodes of pipe or rods shall preferably be in one piece and shall be driven to a depth of at least eight feet regardless of size or number of electrodes used.

Exception: 1. In basements where an eight foot rod or pipe cannot be driven because of the low ceiling height and where the base-

ment 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.

Exception: 2. Where rock is encountered, rods may be driven obliquely for a length of at least 8 feet or plates shall be used.

Where driven pipes or rods are used, at least one rod shall be used at each location called for if a resistance of 25 ohms or less can be obtained. Where this resistance cannot be obtained with one rod, 2 rods or pipes shall be installed at least six feet apart.

Artificial grounds may be arranged to minimize the potential gradient along the surface of the earth by use of radial connecting wires underneath the earth surface or by other suitable means.

Pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel, or other poor conducting materials.

Each artificial electrode used shall be separated at least six feet from any other electrode, including those used for signal circuits, radio, lightning rods, or any other purpose. (See 1036S)

(d) If the metal frames of buildings are used the ground connection must be such that there is a resistance to ground substantially less than 25 ohms.

(e) All single artificial grounds on customers' premises shall be tested when installed. All grounds or grounding systems installed by the utility shall be inspected and/or tested periodically and if found deficient shall be made to comply with the requirements of this code.

Order 1036. Grounding Conductor.

(A) A grounding conductor for a direct-current supply system shall have a current-carrying capacity not less than that of the largest conductor supplied by the system and in no case less than that of No. 8 wire.

(B) A grounding conductor for an alternating current system shall have a current-carrying capacity not less than one-fifth that of the conductor to which it is attached and in no case less than that of No. 8 copper.

(C) The grounding conductor of a wiring system shall be of copper or other noncorrodible material. Except in case of bus bars the grounding conductor shall be without joint or splice throughout its length.

(D) The grounding conductor of an interior wiring system shall comply, both as to insulation and installation (except as otherwise provided in 1036I) with one of the systems of circuit wiring recognized in Section 130.5.

(E) 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.

(F) No switch shall be inserted in the grounding conductor in supply stations unless it is in plain sight, and provided with distinctive marking and effectively isolated from unqualified persons.

(G) The grounding conductor for conduit and other metal raceway or inclosure for wires, may be a wire or other conductor, insulated or bare, and run either separately or in cable or other wire assembly, or it may be a rigid conduit or steel pipe, except that under conditions favorable to corrosion, such grounding conductor shall be of copper or other noncorrodible material and shall meet the same installation requirements as apply to grounding conductor for an interior wiring system. The grounded circuit conductor of an interior wiring system shall not be used for grounding conduit, cable armor, equipment, and the like.

(H) Where (1) service raceway or service cable armoring or sheath, (2) service cabinet or cutout box, and (3) interior metal raceway or cable armor system, are bonded together by means of jumpers, clamps, or other devices approved for the purpose, a single grounding conductor may be used. If not so bonded together, independent grounding conductors shall be provided.

(I) The grounding conductor of an interior wiring system, if not smaller than No. 4, or if carried in conduit or cable armor, may be used also as the grounding conductor for conduit and other metal raceways or inclosures for wires, including service conduit or cable sheath and service equipment, provided such conductor meets the current-carrying requirements of 1036L or 1036M, whichever calls for the larger conductor. Such common grounding conductor may be either bare or insulated and may be attached to the surface on which it is carried, without use of knobs, tubes, or insulators except when within eight feet of the floor, earth or platform from which the grounding conductors are accessible to unauthorized persons or the public. (See 1036P(2))

(J) Fixed equipment may be grounded in one of the following ways:

For grounding in hazardous locations see Section 133.2.

(1) By means of the metal inclosure of the conductors feeding such equipment, when such metal inclosure is con-

nected to the exposed parts of the equipment by approved fittings.

(2) By means of a grounding conductor run with the circuit conductors in wire assemblies, when such conductor is connected to the exposed parts of the equipment and to the grounded conduit or armored cable system by approved fittings.

(3) By a separate grounding conductor complying with 1036G and 1036L.

(4) By permission of the authority enforcing this code other means for grounding fixed equipment may be used.

(K) Portable equipment may be grounded in one of the three following ways:

For grounding portables in hazardous locations see Section 133.2.

(1) By means of the metal inclosure 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 inclosure.

(2) By means of a grounding conductor run with the circuit conductors in wire assemblies, provided an approved multi-prong plug or equivalent is used, one prong for the purpose of connecting such grounding conductor to the grounded conduit or armored cable system.

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

(L) The size of the wire, conduit, or steel pipe used as the grounding conductor for interior conduit, cable armor, and other metal raceways or inclosures, shall be not less than the following:

Capacity of Automatic Overcurrent Protective Device in Circuit Ahead of Equipment, Conduit, etc. Not Exceeding (Amperes)	Size of Grounding Conductor: Copper Wire (No.)	Size of Grounding Conductor: Nominal Diameter of Conduit or Pipe (Inch)
30	14	½
60	10	½
100	8	½
200	6	½
400	4	¾
600	2	¾
800	0	1
1000	00	1
1200	000	1

(M) The size of the wire or steel pipe used as the grounding conductor for service conduit or service cable shall be not less than the following: (See 1036I)

Nominal Size of Service Conduit	Service Cable Conductors	Size of Grounding Conductor: Copper Wire (No.)	Size of Grounding Conductor: Nominal Diam. of Conduit or Pipe (Inch)
¾–1 inch	No. 2 or smaller	8	½
1¼–1½ inch	1 or 0	6	½
2 inch	00 or 000	4	¾
2½ inch	300,000 CM	2	¾
3 inch	500,000 CM	0	1
3½–4 inch		00	1
Above 4 inch		000	1

(N) For grounding portable or pendent equipment, the conductors to which are protected by fuses or circuit-breakers at not exceeding 15 amperes, No. 18 copper wire may be used. For grounding portable or pendent equipment fused for more than 15 amperes, the table in 1036L shall be followed.

(O) Metal boxes, cabinets, and all outlets and terminal fittings, when not connected with grounded metal cable sheath, conduit, or other raceway, and when required to be grounded, may be grounded in one of the two following ways:

(1) By a grounding conductor run with the circuit conductors in wire assemblies.

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

(P) *Insulation and Guarding.* (1) The grounding conductor for systems when not consisting of or inclosed in metallic piping, shall have an insulating covering on the conductor which complies with all requirements of this code applying to wires of the voltage of the circuit to which the grounding conductor is attached except as noted in Paragraph I. Where a grounding conductor, is installed in steel conduit or in armored conduit, it shall be bonded to the conduit or armor at both ends, in which case a bare conductor may be used within the conduit. (See also Order 1239)

Exception 1. In electrical supply stations, transformer vaults, and manholes substantial bare grounding conductors may be used.

(2) When within eight feet of the earth, platform or floor from which grounding conductors are accessible to unauthorized persons or the public, or when exposed to mechanical injury, grounding conductors shall be protected by adequate guard.

(3) Wires used for grounding conductors, if laid underground, shall, unless otherwise mechanically protected, be laid slack to prevent their being readily broken.

(4) If the resistance of the ground connection is in excess of three ohms, the grounding conductors shall be protected and guarded by being inclosed in insulating conduit or molding to protect persons from injury by coming in contact with it.

(5) Lightning-arrester grounding wires shall be protected by nonmagnetic material unless the grounding conductor is electrically connected to both ends of the protective covering.

(Q) The grounding conductor for instrument cases and secondary circuits of instrument transformers shall not be smaller than No. 12 if of copper, or if of other metal, shall have equivalent current-carrying capacity.

(R) Secondaries of current and potential instrument transformers and/or the cases of instruments connected to such circuits, when grounded, shall not be connected with a grounding conductor used for other circuits or for conduit, equipment, and the like, but shall have an independent grounding conductor except where a general ground bus is provided or where provisions of 1036I are fulfilled.

(S) The grounding conductor for a lightning arrester shall not be connected to an artificial ground electrode which is used for circuits or equipment and the like, (unless a grounding bus with resistance to ground of less than 3 ohms is used) but shall be kept at a distance of at least 6 feet. A greater distance is recommended. The grounding conductor shall have a current-carrying capacity sufficient to insure the continuity and continued effectiveness of the path to ground under conditions of excess current caused by or following the discharge of the arrester. No individual grounding conductor shall be smaller than No. 6. (See 1037J (1) and (2))

(T) A grounding conductor may be run in the same conduit, metal raceway, etc. with other wires of the system to which it is connected.

(U) The path to ground provided by a system grounding conductor shall, in general, have current-carrying capacity sufficient to insure the continuity and continued effectiveness of the path under conditions of excess current caused by accidental grounding of any normally ungrounded conductor of the circuit of the system to which it is electrically connected.

Order 1037. Grounding Connections.

(A) The grounding connection for interior metal raceways, cable armor, and the like, shall be made at a point as near as practicable to the source of supply and shall be so arranged that no raceway and the like is grounded through a run of smaller size than is called for by 1036L.

(B) The grounding conductor shall be attached to circuits, conduits, cabinets, equipment and the like, which are to be grounded, by means of suitable lugs, clamps, blocks, or other approved means. For conduit, armored cable, frames of generators, motors and transformers, and other noncurrent-carrying metal parts of electrical equipment, the point at which the grounding conductor is attached shall be accessible if practicable.

(C) 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 to which the conductor is soldered or otherwise connected in an approved manner, 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. 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. For the grounding conductor of an interior wiring system the sheet metal strap type of ground clamp is not considered adequate unless it has a rigid metal base seated on the waterpipe or other electrode and the strap is of such material and dimensions that it is not liable to stretch during or after installation.

The ground connection to metallic piping systems and conduit shall be made in such a manner that good electrical contact between the grounding wire and pipe surface is secured, and that the possibility of increase in resistance of the joint through corrosion is minimized. All connections shall be accessible.

Note: With bell and spigot joint pipe it may be necessary to connect to several lengths where circuits or equipment of large current-carrying capacity are being grounded. For this condition the most satisfactory method of making the ground connection consists in drilling a hole in the bell, tapping it, and screwing in a brass plug to which the ground wire is soldered. The joint thus made and the surface of the pipe in the immediate vicinity should be heavily coated with pitch or equivalent material to prevent corrosion. The point of connection should be accessible and its position recorded.

(D) 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 inclosed in metal, wood, or equivalent protective covering.

(E) Where a nonconductive protective coating such as paint or enamel is used on equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good metallic connection.

(F) *Piping Connections.* Ground connections to metallic piping systems shall be made (except as permitted below) on the street side of meters, but connections may be made immediately inside building walls to secure accessibility for inspection and test. (Water piping systems should be used if available)

Exception: (1) When meters are located outside of buildings or in concrete pits within buildings where piping connections are embedded in or under concrete flooring, or other flooring reasonably insuring against the disturbance of the pipe, the ground connections may be made on the building side of the meters, if meters are suitably shunted.

(2) Ground Connection for noncurrent-carrying parts such as equipment or metal raceway systems, (but not for circuits) may be made to the piping system at a point near the part to be protected, provided there are no insulating joints in the pipe to prevent a good ground. In such cases, care should be taken to electrically connect all parts of the piping system liable to create a hazard (if they become alive) and to shunt the pipe system where necessary around meters, etc., in order to keep the connection with the underground piping system continuous.

(G) Bonding jumpers between grounding electrodes and around water meters, gas meters, unions, and the like, shall be of copper or other noncorrodible metal and shall be of sufficient size to have current-carrying capacity not less than is required for the corresponding grounding conductor. They shall be attached by one of the methods given in Order 1037B.

(H) Bonding jumpers in cabinets and the like shall be of copper wire or the equivalent and of such size as to have current-carrying capacity not less than is required for the corresponding grounding conductor. They shall be attached in the manner provided in Order 1037B.

(I) Where two or more grounding conductors are used under a condition where, in accordance with the provisions of Orders 1036(H), 1036(I), a common grounding conductor is permissible, a common connection to the grounding electrode may be employed. In all other cases each grounding conductor shall have an independent connection to the grounding electrode.

(J) (1) Acceptable lightning protective devices having valve characteristics may have their ground leads connected directly to the secondary neutral where extended metallic water systems are available and used, provided that the neutral or protective device is connected to ground at the transformer and the utility connects the neutral to an extensive underground metallic water system at least 20 feet from the transformer. The second ground may be omitted if the neutral is connected to an extended water system at at least two customers' entrances.

(2) Where extensive underground metallic water systems are not available, acceptable lightning protective devices having valve characteristics may have their ground leads connected to the secondary neutral through a gap having a breakdown of not less than 15 K. V. r. m. s. 60 cycle provided that the protective device's ground lead is run directly to ground and the utility places a ground on the secondary neutral at least 20 feet from the protective device ground.

(K) Where the grounding electrode is also used for grounding lightning rods, as for example, in case of continuous metallic water pipe systems, the grounding connection shall be entirely independent of, and separated from, the lightning rod connection to the piping system.

PART I

ELECTRICAL SUPPLY STATIONS, SUBSTATIONS AND EQUIPMENT

SECTION 110. SCOPE OF ORDERS

Order 1100. Electrical Supply Equipment in Stations, Substations, Factories and Elsewhere.

The following orders (1100–1194) apply to the electrical supply equipment of indoor and outdoor stations and substations. Provided the equipment is in separate rooms or enclosures, under control of properly qualified persons and accessible only to such persons, the orders also apply to similar equipment, including generators, motors, storage batteries, transformers, lightning arrestors, etc., when installed in factories, mercantile establishments, vehicles, or elsewhere. (See also Section 130, Part 3.)

For the intent of the rules, waivers, etc., see Order 1013.

SECTION 111. GENERAL PROTECTIVE ARRANGEMENTS OF STATIONS AND SUBSTATIONS

Order 1110. General Requirements for Rooms and Spaces.

(A) *Inclosure of Rooms and Spaces.* Rooms and spaces shall be arranged with fences, screens, partitions, or walls so as to prevent entrance of unauthorized persons or interference by them with equipment inside, and the entrances not under observation of an authorized attendant shall be kept locked. Signs prohibiting entrance to unauthorized persons shall be displayed at entrances.

(B) *Rooms and Spaces.* All rooms or spaces in which electrical supply equipment is installed shall comply with the following requirements.

(1) Fireproof Construction. They shall be as far as practicable, noncombustible.

(2) Storage and manufacturing processes. They shall be used neither for the storage of material nor for manufacturing processes causing hazard to electrical operators, except those materials or processes attendant upon the production or distribution of a supply of electrical energy.

(3) Hazardous Conditions. They shall be free from combustible dust or flyings, flammable gas, or acid fumes in dangerous quantities. (For battery rooms, see Section 114. For auxiliary equipment in hazardous locations, see Order 1127) Also see General Orders on Dusts, Fumes, Vapors and Gases published by the Industrial Commission.

(4) Ventilation. They should be well ventilated. See Industrial Commission codes.

(5) Moisture and Weather. They should be dry. In outdoor stations or stations in wet tunnels or subways, all live parts of equipment should be enclosed in weatherproof cases, unless the equipment is suitably designed to withstand the prevailing atmospheric conditions.

(C) *Rotating Machinery.* Rotating machinery shall be installed upon suitable supports or foundations and if necessary secured in place.

Order 1111. Illumination (See also Order 1144)

(A) *Under normal conditions.* Rooms and spaces where electrical apparatus or machinery is located shall have means for artificial illumination in accordance with the following table. The means of illumination shall be maintained ready for use at all times.

Note: It is not intended that this rule should require permanent lighting in switch cells and similar small spaces occupied by electrical apparatus where permanent lighting is impracticable. The Industrial Lighting Code of the Wisconsin State Industrial Commission includes general standards of illumination required from the point of view of safety.

TABLE NO. 1

Illumination Intensities

	Minimum Foot-Candles	Modern Practice Foot-Candles
(1) Switchboard inst. gauges, switches, etc.	1	2 to 4
(2) Switchboards with no exposed live parts	½	1 to 2
(3) Storage battery room	½	1 to 2
(4) Generating room, boiler room, pump room (at machinery or exposed live parts)	1	2 to 4
(5) Stairways and passageways (measurements made at floor level) where there is moving machinery, exposed live parts, hot pipes, etc.	1	2 to 4
(6) Any traversed space (measured at floor level)	¼	1 to 2

Note: The above illumination values are to be measured at working surfaces, except as stated.

The "minimum foot-candles" specify the lowest illumination for safety, but the "modern practice foot-candles" are recommended.

(B) *Emergency Lighting.* A separate emergency source of illumination shall be provided in every station where an attendant is located. This source shall be from an independent generator, storage battery, gas main, or other suitable source.

Note: Flame lamps (gas or oil) should not be used in battery rooms.

(C) *Shading of Lamps.* Overhead and local lamps shall be shaded as required by the Industrial Lighting Code published by the Industrial Commission.

(D) *Fixtures, Pendants and Plug Receptacles.* (See also Section 131.4 of Part 3)

Arrangements of permanent fixtures and plug receptacles shall be such that portable cords need not be brought into dangerous proximity to live or moving apparatus. All lamps shall be arranged to be controlled, replaced, or trimmed from safely accessible places.

Pendent conductors shall not be installed where they can be readily moved so as to bring them in contact with live parts of electrical supply equipment.

(E) *Attachment Plugs.* Portable conductors shall be attached to fixed wiring only through separable attachment plugs which will disconnect all poles by one operation.

Order 1112. Buildings, Yards and General Safety.

(A) *Buildings to Comply with Building Code.* Buildings in which electrical supply equipment is installed shall be constructed in every detail to comply with the Building Code published by the Industrial Commission.

(B) *General Orders on Safety to be Complied With.* Floors, passageways, stairways, floor openings, platforms, runways, moving machinery, etc., shall be constructed and safeguarded as required by the General Orders on Safety published by the Industrial Commission.

(C) *Protection from Rain and Falling Objects.* Electrical supply equipment located outdoors, when necessary, shall be protected against injury from rain, snow, sleet, flying or falling objects.

(D) *Exits.* Each room or space and each working space about equipment shall have suitable means of exit which shall be kept clear of all obstructions.

If the plan of the room or space and the character and arrangement of equipment are such that an accident would be liable to close or make inaccessible a single exit, as in the case of long narrow rooms, platforms, passageways, spaces behind switchboards, or wire and pipe tunnels, a second exit shall be provided if practicable. In all cases the Building Code should be consulted.

(E) *Floors.* Floors shall have even surfaces and afford secure footing. Projecting nails, loose boards, uneven or greasy floors, and slippery floors should be avoided.

Note: Otherwise slippery floors or stairs should be provided with antislip treads.

(F) *Passageways.* Passageways (including stairways) and working spaces shall be unobstructed, and (except such as are used solely for infrequent inspection, construction and repair) shall, where possible, provide at least 6.5 feet headroom. (See Order 1124 for working space) The General Orders on Safety by the Industrial Commission also contain orders applying to passageways.

(G) *Runways and Platforms, Rails and Toe Boards.* (See General Orders on Safety published by the Industrial Commission).

(H) *Stairways, Handrails.* (See General Orders on Safety published by the Industrial Commission.)

(I) *Platforms with Stairways or Stationary Ladders.* (See General Orders on Safety published by the Industrial Commission.)

(J) *Continuity.* The heads of permanent ladders shall be provided with guards such as gates or sliding pipe sections whenever the heading breaks the continuity of a railing adjacent to working space.

For very long ladders occasional landings, turns, or safety loops are recommended.

(K) *Stair Toe Boards.* Toe boards shall, where practicable, be arranged at back of stairway treads where over exposed live or moving parts or over working spaces, passageways, or other stairways.

(L) *Walks and Platforms for Overhead Work.* (See General Orders on Safety published by the Industrial Commission.)

Order 1113. Fire Fighting Appliances.

Each room or space where an operator is in attendance shall be provided with adequate approved fire-extinguishing appliances conveniently located and conspicuously marked.

Note: For proper type or extinguisher to be used on live parts or at other locations see N. F. P. A. Regulations on First Aid Fire Appliances.

Extinguishers which are not approved for use on live parts shall be conspicuously marked with a warning to that effect.

Order 1114. Oil Filled Apparatus.

For the purpose of these rules, oil-filled apparatus is divided into three classes, each of which requires different treatment: (1) Oil switches and circuit-breakers: (See also Section 117) (2) transformers, induction regulators, etc.: (See also Section 115) and (3) lightning arresters: (See also Section 119). The necessary safety precautions depend largely on whether they are located in buildings or outdoors.

(A) *Oil switches or circuit-breakers.* When located on floors of buildings or in galleries, oil switches or circuit-breakers should be separated from other apparatus by adequate nonflammable barriers, or otherwise adequately isolated. Floors and floor drains should be so arranged that oil will quickly collect in a suitable drainage or storage system provided for the purpose either inside or outside of the building as may be advisable.

Where switches or switch compartments are constructed to prevent an appreciable amount of oil being thrown outside of the compartment, exterior drainage or storage systems are not necessary.

When located outdoors they should be adequately isolated.

When located near building walls the walls should be of fire resistive construction and should have doors or windows so located and arranged that burning oil is not liable to pass through them to flammable material or apparatus.

Note: It should be recognized that oil-switch or circuit-breaker failures may depend upon the size and rupturing capacity of the switch or circuit breaker and the short-circuit duty that may be required of it. The short-circuit current depends on the generating capacity supplying the system on which the switch or circuit-breaker is used as modified by the current-limiting characteristics of the system or by special apparatus installed for that purpose. By "generating capacity" is meant all of the apparatus contributing to the short-circuit current.

(B) *Transformers, induction regulators, etc.* See Order 1153. When in buildings, transformers, induction regulators, etc., should preferably be located on lower floors or in basements so that oil which leaks out or is spilled can not drip on other apparatus. Where this is not practicable, adequate provision should be made to prevent leakage on other apparatus. Floors and floor drains should be so arranged that oil will quickly collect in a suitable drainage or storage system provided for the purpose either inside or outside of the building as may be advisable. When the apparatus contains large quantities of oil, each unit or group should preferably be placed in a separate fireproof compartment suitably ventilated. Induction regulators when nonautomatic should be arranged for remote control.

When located outdoors, transformers, regulators, breakers, etc., should be adequately isolated. Provision should be made for quickly draining away to a safe distance any oil that may be spilled. This may be done by ditches and drains or the oil may be absorbed and danger of spreading removed by paving the yard around the transformers or other devices with cinders or other absorbent material to a depth of several inches.

When located in buildings, transformer tanks containing large quantities of oil shall, where practicable, be so arranged that approved fire-quenching material may be introduced above the oil inside the tank or in the surrounding compartment, except where tanks are completely filled with oil or where the space above the oil is filled with an inert gas.

(C) *Lightning arresters.* When located in buildings, lightning arresters containing oil should be separated from other equipment by fire walls adequate to completely isolate them in case of fire.

When located outdoors they should be adequately isolated. Provision for quickly draining away oil should be made as indicated for transformers in (b) above.

SECTION 112. PROTECTIVE ARRANGEMENTS OF EQUIPMENT

Order 1120. General Requirement.

All electrical supply equipment shall be of such construction and so installed and maintained as to reduce the life and fire hazard as far as practicable.

Order 1121. Inspections.

(A) *Regular Equipment.* Electrical supply equipment shall comply with these orders when placed in service, and shall thereafter be periodically cleaned and inspected. Defective equipment shall be put in good order or permanently disconnected. Defective wiring when hazardous shall be repaired or removed.

(B) *Idle Equipment.* Infrequently used equipment or wiring maintained for future service should be thoroughly inspected before use to determine its fitness for service.

(C) *Emergency Equipment.* Equipment or wiring maintained for emergency service should be periodically inspected and, where necessary, tested to determine its fitness for service.

(D) *New Equipment.* New equipment should be thoroughly inspected before being put in service.

Order 1122. Guarding Shaft Ends, Pulleys and Belts, and Suddenly Moving Parts.

(A) *Transmission Machinery.* This code is supplemented by the General Orders on Safety and other Industrial Commission requirements which specifies methods for safeguarding pulleys, belts, and other equipment used in the mechanical transmission of power.

(B) *Suddenly Moving Parts.* Parts of equipment which move suddenly in such a way that persons in the vicinity are liable to be injured by being struck, such as handles and levers of circuit breakers, shall be guarded or isolated.

Order 1123. Protective Grounding.

(A) *Grounding Method.* All grounding which is intended to be a permanent and effective protection measure, such as lightning arrester grounding, grounding of circuits, equipment or wire raceways, shall be made in accordance with the methods specified in Section 103 of the Introductory Part.

(B) *Grounding Noncurrent Carrying Metal Parts.* All electrical supply equipment, if operating at more than 150 volts to ground, or if in hazardous locations, shall have the exposed noncurrent-carrying parts, such as frames of generators and switchboards, cases of transformers, lightning arresters and switches, and operating levers, permanently grounded.

It is recommended that exposed noncurrent-carrying parts of electrical apparatus operating at 150 volts or less to ground be permanently grounded.

It is recommended that all metallic guards (including rails, screens, etc.) about electrical supply equipment should be permanently grounded where such grounding will reduce the hazard.

Except in hazardous locations, exposed noncurrent-carrying parts of equipment operating at more than 150 volts to ground may be left ungrounded and either isolated, or guarded, or provided with insulating mats as required for live parts at the same voltage. Such isolation, guarding, or mats should be so arranged that persons can not inadvertently touch these parts while also touching a grounded surface.

Note: Hazardous locations include those where dampness, acid fumes, explosives, inflammable gas, or flyings normally exist. (See Section 133.2 Part 3)

Exception 1: Exposed noncurrent-carrying metal parts of supply equipment of grounded direct-current circuits or series direct-current circuits are exempted from this order, if suitably insulated from the ground and from neighboring grounded surfaces. In addition suitable permanent insulating barrier guards shall be installed so that a person cannot, while touching such insulated frames, at the same time inadvertently touch or stand upon other grounded bodies.

Exception 2: Exposed noncurrent-carrying metal parts of supply equipment for communication circuits are exempted from this order, providing they are suitably insulated from the ground and neighboring grounded conductors and surfaces.

Exception 3: Metal shell sockets and metal guards of portable lamps, if suitably insulated, are exempted from this order.

(C) *Grounding Equipment During Repairs.* Electrical equipment or conductors normally operating at more than 750 volts, on or about which work is occasionally done while separated from a source of electrical energy by switches or disconnectors only, shall be provided with some means, such as switches, connectors, or readily accessible ground conductor, for grounding them. (See orders 1423 and 1424)

Order 1124. Guarding Live Parts.

(A) *Where required:* (1) Guards shall be provided for all parts exceeding 300 volts to ground unless the boundary of the guard zone around the part has a vertical clearance of more than 7 feet 6 inches for voltages up to 7,500, and 8 feet 6 inches for voltages of more than 7,500, above any permanent supporting surface for workmen, or a horizontal clearance of more than 3 feet from the nearest edge of any such surface, or both. This includes parts exposed through windows, wall openings, etc.

Exception: Guards need not be provided where it is necessary to permit routine inspection of rotating equipment as required under operating conditions.

Note: The rule applies to the electrical parts energized or considered available for service in temporary or partially completed installations, as well as to permanent installations.

Definitions: The guard zone means the space of minimum clearance from guards to electrical parts where guards may be installed by workmen without definite engineering design. The radius of this zone varies with the voltage as specified in column 4 of the table No. 2. (See Order 1422, C. of the code for working clearances above live parts).

"Permanent supporting surfaces for workmen" include floors, platforms, or structures used regularly and frequently by workmen for inspections and maintenance near live adjacent parts: runways, ladders, stairways, etc.

(2) Parts over or near frequently traveled passageways through which material may be carried, or in or near spaces, such as corridors, storerooms, boiler rooms, etc. used for non-electrical work, should, where practicable, be guarded or given clearances in excess of those specified as may be necessary to secure reasonable safety. The guards should be substantial; should, where practicable, completely shield or inclose without openings the parts; and when in spaces used for non-electrical work should be removable only by means of tools or keys.

TABLE NO. 2

Minimum Clearances from Live Parts

1	2 Minimum Vertical Clearance of Unguarded Parts		3 Minimum Horizontal Clearance of Unguarded Parts		4 Minimum Clearance from Guards to Parts. Radius of Guard Zone
Voltage Between Phases	Feet	Inches	Feet	Inches	Inches
600	7	8	3	2	2
2300	7	9	3	3	3
6600	7	10	3	4	4
11000	9	0	3	6	6
22000	9	3	3	9	9
33000	9	6	4	0	12
44000	9	10	4	4	16
66000	10	5	4	11	23
88000	11	0	5	6	30
110000	11	7	6	1	37
132000	12	2	6	8	44

Note: Interpolate for intermediate values.

The clearances in column 4 of this table are not a requirement for definite engineering design of either apparatus or guards, but are solely for the guidance of workmen installing guards without such design.

For example, the minimum clearances in the table above are not intended to refer to the clearances between live parts and the walls of cells, compartments, or similar inclosing structures. They do not apply to the clearances between bus bars and supporting structures, nor to clearances between the blade of a disconnecting switch and its base.

(3) Parts of indeterminate potential, such as telephone wires exposed to induction from high-tension lines, ungrounded neutral connections, ungrounded frames, ungrounded parts of lightning arresters, ungrounded instrument cases connected directly to the high-voltage circuit, etc., shall be classified and, where practicable, guarded on the basis of the maximum voltage which may be present.

(B) *Strength of Guards.* Guards shall be sufficiently strong and shall be supported rigidly and securely enough to prevent them from being displaced or dangerously deflected by a man slipping or falling against them.

(C) *Types of Guards.* (1) Location or isolation. Parts having clearances equal to or greater than specified in (a) above are guarded by location. Parts are guarded by isolation when all entrances to inclosed spaces, runways, ladders, etc., are kept locked or warning signs posted at all entrances, in which case no other permanent guards need be supplied.

(2) Grounded metal cable sheaths. These are suitable guards except where exposed to mechanical injury. Where so exposed metal conduit or other suitable guards should be provided.

(3) Railings. Railings are not substitutes for complete guards, and if used shall be located at a horizontal distance of at least 3 feet (and preferably not more than 4 feet) from the nearest point of guard zone, which is less than 7½ feet above the floor.

(4) Shields or inclosures. Guards inside of the guard zone or less than 4 inches outside, shall completely inclose the parts from contact up to the heights listed in column 2 of table No. 2 and under Order 1124 (A). They shall not be closer to the live parts than listed in column 4 of the table under Order 1124 (A) except when suitable insulating material is used with circuits of less than 7,500 volts. (See note under table in Order 1124 (A)). If more than 4 inches outside of the guard zone, the guards need not extend more than 7½ feet above the floor. Covers or guards, which must at any time be removed while the parts they guard are alive, should be arranged so that they can not readily be brought in contact with live parts.

(5) Insulating Covering on Conductors or Parts. The insulating covering on parts exceeding 750 volts to ground shall not be considered a protection. For parts less than 750 volts, positive barriers, inclosures, or similar arrangements are preferable, but in dry places where not exposed to mechanical injury, varnished-cloth tape, or other insulation suitable for the voltage involved may be used as a guard. The taping over connections shall be of a type and

thickness suitable for the voltage involved. Friction tape is not acceptable as the sole protection.

Exception: On circuits not exceeding 7500 volts between phases, when other guarding is impracticable, insulation suitable for the voltage involved may be used back of the switchboards or in equivalent sheltered locations. Insulating mats or platforms shall be provided so that an operator can not readily touch the insulating covering without standing on the mats.

(6) Mats. Suitable insulating mats placed so that a person can not inadvertently come in contact with the live parts without standing on the mat may be used in the following cases:

Parts less than 750 volts to ground exposed at switchboards, switches, or on rotating machinery.

Disconnect switches less than 7,500 volts between phases mounted on back of switchboards or in similar sheltered locations when barriers are placed between each blade so as to extend beyond the disconnected parts in any position. Other means of guarding may be used where convenient.

Ungrounded frames of existing high-voltage series generators.

As provided for in paragraphs (c) (5) and (c) (8) of this rule.

Mats should be of rubber, or in dry locations they may be of wood fastened with wood pins, cork matting, or heavy (one-fourth inch) linoleum laid without joints and without metal fastenings. A "nonslip" surface should be maintained and the mats should be laid and maintained so as to reduce the tripping hazard to a minimum.

Note: Beveled edges will help in many cases.

(7) Parts below supporting surfaces for persons. The supporting surfaces above live parts shall be solid without openings exceeding one-eighth inch in width. Toeboards at least 6 inches high shall be provided at all edges.

(8) Special rules for plug-type switchboards. A mat is a suitable guard when placed so that the operator must stand on it when operating the plugs. Suitable guards on handles of all plugs shall be provided.

(D) *Parts of less than 300 volts to ground.*

It is recommended that live parts of more than 150 volts to ground be inclosed or guarded when in exposed locations.

Order 1125. Working Space About Electrical Equipment.

(A) *Where required.* Adequate and readily accessible working space with secure footing shall be maintained

about all electrical parts or equipment which require adjustment or examination when exposed while in service.

(B) *Width of working space.* The horizontal clearance from the farthest edge of the working space to the nearest live part of more than 300 volts to ground, exposed after removing guards, shall be not less than 3 feet plus the guard zone radius as given in column 4 of the table in Order 1124. (When the live parts are on only one side, column 3 of the table in Order 1124 gives the minimum permissible value for the total width of the free space). See also Order 1112 F for headroom.

(C) *Elevated parts.* Clearance about normally elevated or isolated parts requiring occasional adjustment should be provided so the men need not come within the danger zone (See Order 1422 C of this code) around adjacent energized parts, unless guarded in accordance with Orders 1124 and 1126 inclusive.

Order 1126. Equipment for Work on Live Parts.

(A) *7,500 volts or less between phases.* When it is necessary for men to bring their bodies or any material or tools handled into the danger zone (see Order 1422 B of this code) suitable protective devices, such as rubber gloves, rubber sleeves (if necessary), insulating tools, portable rubber mats or insulating stools, rubber blankets, insulated fuse pullers, testing and grounding devices, switch sticks, etc., should be provided, periodically examined, and kept in safe condition.

(B) *More than 7,500 volts.* Suitable protective devices, such as testing and grounding devices, switch sticks, fuse pullers, special insulated tools, etc., should be provided, periodically inspected, and kept in safe condition. Such devices shall provide an ample margin of safety for the voltage involved and should be constructed so that the workman's body can remain outside of the danger zone. (See Order 1422 C of this code).

Order 1127. Hazardous Locations.

(A) *Inclosure of arcing and heating parts.* In locations where flammable gas or flammable flyings normally exist in dangerous quantities, all parts where sparking, arcing, or dangerous heating is liable to occur shall be inclosed so as to reduce the hazards as far as practicable.

This inclosure shall be by one of the following methods:

(1) By placing in separate compartments or rooms.

(2) By using nonabsorptive, noncombustible casings of the dust-tight type when flammable dust or flyings are present.

(3) By using nonabsorptive, noncombustible casings designed for use in explosive atmospheres when flammable gas exists in dangerous quantities.

(B) *Grounding.* The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded as specified in Section 103.

The Flammable Liquids Code published by The Industrial Commission should be consulted.

Order 1128. Shielding of Equipment from Deteriorating Agencies.

Suitable shields or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads or electrical devices or equipment where susceptible to injury by being installed directly under rotating equipment or in other locations where dripping oil, excessive moisture, steam, vapors, or similar agents exist. (For battery rooms see Order 1145).

Order 1129. Identification.

(A) *Equipment in general.* Electrical supply equipment shall be suitably identified when necessary for safety. The identification may be by position, color, number, name plate, label, design, or other means, but the method of identification chosen shall be uniform throughout any one system. (See Order 1174 A for switches.)

The voltage and intended use shall be shown when important.

Identification marks should not, if possible, be placed on removable covers or casings, such as instrument covers and disconnector compartment doors, where the interchanging of these removable parts might lead to accident.

(B) *Generators and motors.* Generators and motors shall each be provided with a name plate giving the maker's name, the rating, normal full-load speed and the voltage.

SECTION 113. ROTATING EQUIPMENT (THIS INCLUDES GENERATORS, MOTORS, MOTOR GENERATORS, AND CONVERTERS)

Order 1130. Speed-control and Stopping Devices.

(A) *Speed limits for prime movers.* Prime movers driving generating equipment shall be provided with automatic speed-limiting devices, where harmful overspeed can otherwise occur, in addition to their governors, if necessary as with some types of steam turbines.

(B) *Stops for rotating equipment.* Stopping devices, such as switches or valves which can be operated from locations convenient to machine operators, shall be provided for prime movers or motors driving generating equipment.

Devices which operate in such a way that the development of defects or their becoming inoperative will stop the units protected should be used where practicable.

Controls to be used in emergency for machinery and electrical equipment should be so located as to permit operation with a minimum of danger during such emergency (See Order 1175 for fuses and circuit-breakers).

(C) *Speed limit for motors.* Machines of the following types shall be provided with speed-limiting devices unless their inherent characteristics 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.

(1) Separately excited direct-current motors.

(2) Series motors.

(3) 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.

Note: The required limitation of speed may be obtained by the use of a relay, centrifugal switch or other similar device which will cut off the supply of energy when excessive speed is attained.

(D) *Low-voltage or under-voltage protection.* All motors so employed or arranged that an unexpected starting of the motor is a hazard, shall be equipped with low-voltage protection which will automatically cause and maintain the interruption of the motor circuit when the voltage falls below an operating value.

Exception: Those motors with an emergency or essential use or where the opening of the circuit will cause a special hazard to life or service are exempted.

(E) *Adjustable speed motors.* Adjustable speed motors, if controlled by means of field regulation, shall be so equipped and connected that the field can not be weakened sufficiently to permit dangerous speed.

(F) *Protection of Control Circuits.* Where speed-limiting or stopping devices are electrically operated, the control circuits by which such devices are actuated shall be in

conduit or otherwise protected from mechanical injury, in accordance with Order 1161.

Order 1131. Guards for Live Parts.

(A) *Guards on rotating equipment.* Guards complying with Order 1124 shall be provided.

(B) *Access to live parts.* Where necessary, steps and handrails shall be installed on or about large machines to afford ready access to live parts which must be examined or adjusted during operation.

(C) *Frame switches.* Where switches are installed on the frames of generating equipment for the purpose of reducing inductive voltage in generator and converter field coils they shall be suitably constructed or guarded to prevent passersby from inadvertently coming in contact with the live parts, to protect persons handling them, and to prevent their being accidentally opened or closed.

(D) *Arcing shields.* Suitable shields or barriers other than rails shall be provided where practicable to prevent arcing on large commutators or any other parts of moving apparatus from injuring persons in the vicinity, as in the case of narrow working spaces located immediately above or beside such equipment.

Exception: Twenty-five cycle apparatus of less than 150 volts to ground is exempted.

It is recommended that where suitable shields have not been installed, goggles should be available.

Order 1132. Grounding Machine Frames.

(A) *Grounding machine frames.* All frames of rotating electrical equipment shall be permanently grounded except as permitted below and in Order 1123.

(B) *Coupled machines.* Where two or more machines, either of which operates at more than 150 volts to ground, are mechanically coupled together and the operator can touch the frames of more than one at a time, the frames of all such shall be permanently grounded or bonded together electrically.

Exception: This rule may be waived with high-voltage series generator sets in existing installations where for operating reasons the generators must have their frames insulated from the ground and the motor frame is grounded, and where it is impracticable to place insulating barriers between the grounded and ungrounded frames.

(C) *Auxiliaries.* Exciters and auxiliary circuits electrically connected to generators or other machines of more than 750 volts to ground (with frames ungrounded) shall be installed, protected, and identified as machines and circuits of the same voltage as that of the machine for which they are auxiliaries.

Order 1133. Terminal Bases and Bushings.

(A) *Terminal bases.* Terminal bases, when used on motors or generators should preferably be of suitable noncombustible, nonabsorptive, insulating material, such as slate, marble or porcelain.

(B) *Bushings.* Bushings where used for wires coming through frames of motors or generators should preferably be of porcelain, suitable composition material, or of hardwood properly filled, except that soft rubber may be used if not exposed to oils, grease or other deleterious substances in such quantities as to cause their rapid destruction.

Order 1134. Deteriorating Agencies.

(A) *Protection required.* Suitable shields or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads, balance coils, or other electrical devices belonging to motors and generating equipment where installed directly under equipment or in other locations where dripping oil, excessive moisture, steam vapors, or similar injurious agents exist.

(B) *Grounding.* The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded.

Order 1135. Motors.

(A) *Control.* If the starting is caused automatically (not manually) as, for example, by a float switch, or if the starting device or control switch is not located close to the motor and all parts of the machinery operated, the starting arrangement shall be designed so that it can positively be kept open by means of locks or equivalent devices.

(B) *Motors in hazardous locations.* Motors with their auxiliary equipment, at which sparking or arcing or high temperature is liable to occur, when in rooms normally containing explosives, flammable gas, or flammable flyings shall be so installed, as to reduce the hazard by inclosure in an adequately ventilated separate compartment, by solidly inclosed equipment designed for use in explosive atmospheres, or, when protected against flyings only, by partitioning off a space or by a suitable boxing.

Motors should be protected from dust. Inclosed-type mo-

tors are recommended in dusty places, being preferable to boxing.

Where practicable, motors permanently located on wooden floors should be provided with suitable drip pans.

SECTION 114. STORAGE BATTERIES

The following orders (except Order 1143) apply only to storage batteries exceeding 50 kilowatt-hours capacity at the eight-hour rate of discharge.

Order 1140. Isolation.

Storage batteries shall be made inaccessible to other than properly qualified persons by being placed in a separate room or inclosure.

Order 1141. Ventilation.

Rooms or inclosures containing storage batteries shall be so ventilated as to remove acid spray and prevent dangerous accumulation of flammable gas.

The battery room ventilating system shall be so arranged as not to carry any gases therefrom into other rooms or spaces of the building where electrical apparatus or equipment is located.

Communication of drafts to other rooms should be prevented.

Order 1142. Suitable Supports and Floors.

The cells, except small cells of insulating material set in sand trays, or shelves, or otherwise separated from the floors, shall be supported by suitable insulators, such as glass or thoroughly vitrified and glazed porcelain. Suitable drainage or other means shall be provided beneath cells to prevent the accumulation of electrolyte in case of leakage or spraying. Acid resistive floors, such as vitrified brick set in pitch, are recommended where large batteries are installed.

Order 1143. Guarding Live Parts in Battery Rooms.

(A) *Separation of parts of more than 150 volts.* The arrangement of cells and connections shall be such that any two current-carrying parts between which a voltage exceeding 150 exists shall be properly guarded if the parts are otherwise so exposed that persons are liable to make accidental contact with both at the same time.

(B) *Precaution against parts of more than 150 volts.* No conductor of more than 150 volts to ground shall be

placed in any passageway, unless guarded or isolated by elevation.

(C) *Form of guards.* Guards shall comply with Order 1124.

Order 1144. Illumination.

Storage battery rooms should be lighted, if practicable from outside lamps. Heating devices with open flames or exposed incandescent resistors shall not be installed.

If lamps are inside, only incandescent electric lamps in keyless porcelain or composition sockets, controlled from points not exposed to battery vapor, shall be used.

It is recommended that switches and incandescent lamps located in battery rooms be put in vapor-proof inclosures.

Order 1145. Acid Resistive Coverings.

Conductors in battery rooms, if of such material or so located as to be liable to corrosion, shall have suitable protective coverings or coatings, unless the ventilation is such as to render this unnecessary.

SECTION 115. TRANSFORMERS, INDUCTION REGULATORS, RHEOSTATS, GROUND DETECTORS, AND SIMILAR EQUIPMENT

Order 1150. Current Transformer Secondary Circuits.

(A) *Short-circuiting.* Secondary circuits of current transformers, including constant-current and instrument transformers, shall be provided with means (such as permanent connections for jumpers) for short-circuiting them which can be readily connected while the primary is energized and which are so arranged as to permit the removal of any instrument or other device from such circuits without opening the circuits.

(B) *Protection when of more than 7,500 volts.* Where primaries are of more than 7,500 volts, secondary circuits unless otherwise adequately protected from injury or contact of persons, shall be in permanently grounded conduit.

Order 1151. Grounding Low-voltage Circuits of Instrument Transformers.

The low-voltage circuits of all instrument transformers shall be permanently grounded unless the circuits are installed, guarded, and plainly identified as required for the

high-voltage circuits of the transformers, in accordance with Order 1160.

Note: This will sometimes require marking to distinguish such a low-voltage circuit from others with which it is associated, but which are protected by ground connections.

Order 1152. Grounding Transformer Cases.

The metal case or exposed frame of each transformer, reactor, induction regulator, and similar equipment, which is located where dampness or flammable gas normally exists, or which is connected to a circuit operating at more than 150 volts to ground, shall be permanently grounded.

Exceptions: Exception is permissible in accordance with Order 1123B in locations free from flammable gas, where the entire transformer is isolated or guarded as required for the highest-voltage circuit connected with the transformer, and is plainly and conspicuously identified as of that voltage.

Order 1153. Location and Arrangement of Power Transformers.

Transformers shall be installed according to one of the following methods:

(1) On poles or (when permitted by local authority) on walls of buildings, and in compliance with the overhead line rules. (See part 2 for mounting and wiring, also 1033D.)

(2) In outdoor inclosures such that unauthorized persons can not, without special effort, come in contact with any part of the casings or wiring.

(3) In ventilated transformer vaults or rooms which shall be made inaccessible to unauthorized persons.

Where the amount of oil in transformer casings is considerable and the transformers are located in buildings used for other than station purposes, they should be placed in suitable transformer vaults with not less than a 6 inch noncombustible sill at the doorway. The floor should be drained to some convenient point outside the building in which the vault is installed.

(4) In rooms containing other equipment.

If in stations, such transformers should be isolated from other equipment and oil sill or suitable arrangements for drainage should preferably be provided.

Order 1154. Resistance Devices.

Rheostats shall be not less than 1 foot from combustible material or separated therefrom by a slab or panel of noncombustible, nonabsorptive material of suitable thickness, not less than one-half inch, somewhat larger than the rheostat, and secured in place by bolts independently of the rheostat supports.

Rheostats or resistance devices shall not be placed where spattering molten metal due to high temperature in the rheostat may fall upon flammable material or spaces frequently occupied by persons.

Rheostats or resistance devices exposed to excessive dust or flyings should preferably be installed in suitable cabinets or equipped with dust-tight side and face plates. (For installation in hazardous locations see Order 1127).

Order 1155. Ground Detectors.

Every attended station supplying circuits which are not permanently grounded in accordance with Section 103 shall be provided with one or more reliable means of ground detection which can be applied to determine the existence of a ground on any such circuit extending outside the station.

In unattended stations periodic tests should be made.

SECTION 116. CONDUCTORS

Order 1160. Electrical Protection.

(A) *Fuses required.* Conductors shall be suitable for the location, use, and voltage. Conductors should be protected against excessive heating by the design of the system or by suitable fuses or automatic circuit-breakers except as provided in Order 1175.

(B) *Fuses in grounded conductors.* Conductors normally grounded for the protection of persons shall be arranged without fuses or automatic circuit-breakers interrupting their continuity between the source of electrical supply and the point at which the ground conductor is attached, unless the circuit-breaker opens all conductors of the circuit with one operation.

(C) *Circuits exposed to higher voltages.* If exposed through transformer windings or outdoor circuits to higher voltages, circuits of less than 750 volts shall be isolated or grounded unless placed in grounded conduit or other suitable duct or identified and guarded as required for conductors of the highest voltage to which they are exposed.

Order 1161. Precaution Against Mechanical and Thermal Damage.

(A) *Protection against injury.* Where exposed to mechanical injury suitable casing, armor, or other means shall be employed to prevent injury or disturbance to conductors, their insulation, or supports.

(B) *Flame proofing.* Where conductors with insulating coverings are closely grouped and any one is liable to damage from near-by conductors (as sometimes on the rear of switchboards or in cableways) they shall have a substantial flameproof outer covering.

Flame proofing shall be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used.

(C) *Protection against contact.* Large conductors liable to be torn from their supports by the forces to which they are subjected (as by the magnetic fields produced) shall be so supported that they cannot come in contact with the surfaces along which they are run if uninsulated or with other conductors and equipment.

Note: This applies in particular to generator leads and conductors liable to large short-circuit currents.

(D) *Conductors between generators and outside lines.* Conductors between generators and outside lines shall be accessible and supported on approved non-combustible, non-absorptive insulators or placed in approved cable, metal conduit, tile, or other fireproof ducts.

(E) *High temperatures.* Insulated conductors exposed to excessive temperatures shall have insulation which remains effective and does not rapidly deteriorate under such conditions.

Order 1162. Isolation.

All conductors of more than 750 volts, and ungrounded bare conductors of more than 300 volts to ground, shall be isolated by elevation or guarded in accordance with Order 1124, so that no person can inadvertently come in contact with them; provided that busses and bus structures and line connections thereto may be installed in accordance with Order 1125, in suitable locations specially arranged for such purposes.

Order 1163. Guarding Conductors.

(A) *Metal sheathed cable outlets of more than 750 volts.* The insulation of the several conductors of multiple-conductor cable, where leaving the metal sheath at outlets, shall be thoroughly protected from mechanical injury, moisture, and electrical strains by means of a pothead or equivalent method.

(B) *Form of guards.* Guards shall comply with Order 1124.

Order 1164. Guarding in Hazardous Locations.

(A) *Rigid steel conduit.* Conductors in locations where flammable gas normally exists shall be in metal conduit. All fittings and outlets of such conduit shall be electrically and mechanically continuous with the conduit, and the conduit shall be sealed to prevent entrance of gases. (See Order 1332.03c)

Note: This rule does not apply to conductors of large section which obviously can not be placed in conduit, such as copper bars connecting large cells with end-cell switches. This rule does not apply to adequately ventilated locations.

(B) *Insulating supports.* Conductors in damp locations, if neither in conduit nor in waterproof metal sheaths in other suitable ducts, shall be effectively isolated and supported on a suitable type of insulator.

Order 1165. Taping Ends and Joints.

Ends and joints of insulated conductors, unless otherwise adequately guarded, shall have equal insulating covering with other portions of the conductor.

Order 1166. Wiring for Illumination.

Wiring installed for the illumination of the station should be installed and protected as required for similar utilization equipment and conductors in part 3 of the code.

SECTION 117. FUSES, CIRCUIT-BREAKERS, SWITCHES AND CONTROLLERS

Order 1170. Accessible and Indicating.

(A) *Arrangement.* All switches, fuses, automatic circuit-breakers, starting rheostats and other control devices shall be readily and safely accessible to authorized persons, unless remotely controlled. They shall be so arranged or marked as to identify the equipment controlled by them, and (except fuses) shall indicate whether they are open or closed.

(B) *Accidental closing.* Switches shall be so installed as to minimize the danger of accidental operation, and where practicable so that gravity can not close them; such switches as may tend to close by gravity shall be provided with a proper latch or stop block to prevent accidental closing. Where practicable, the blades of knife switches should be dead when the switches are open.

Order 1171. Oil Switches.

Oil circuit-breakers and oil switches shall, wherever practicable, be isolated from other types of switches, and other electrical apparatus to conform to Order 1114 (A).

Remote control of switches and circuit-breakers shall be used on circuits of more than 7,500 volts, or when they may be subject to large short-circuit values.

Note: Remote control may be mechanical, electrical, or other type. It is not intended to prohibit the use of switches and circuit-breakers operated manually by means of levers or poles from a remote position. (See note in Order 1114 (A) for conditions usually applying to electrical systems).

Order 1172. Where Switches are Required.

Suitable disconnectors, switches or circuit-breakers which may be manually operated shall be inserted in all leads to all supply equipment and all outgoing supply circuits, except as listed below.

Exceptions (1) Where two or more pieces of electrical supply equipment or supply lines are operated as a single unit no switch is necessarily required between them.

(2) Switches are not required in transformer vaults except as may be deemed necessary by the engineer in charge to meet operating requirements.

(3) Switches are not required in leads to instrument transformers.

(4) Switches are not required in grounded conductors.

Note: In most cases the switch called for should be capable of opening the circuit under loads. In some cases, as between generators and transformer banks used with them, disconnectors only would be required.

Order 1173. Switches or Other Grounding Devices.

It is recommended that switches or other suitable means be provided, where practicable, to facilitate short-circuiting and grounding equipment or lines for which the operating rules (See Orders 1423 and 1424 of this code), require grounding to protect workmen. (See Order 1123 (C))

Order 1174. Capacity of Switches and Disconnectors.

(A) *Suitability.* Switches used otherwise than as disconnectors shall be of suitable voltage and ampere rating for the circuit on which they are installed and should preferably be marked with the current which they can safely interrupt.

Disconnectors shall be of suitable voltage and ampere rating for the circuit on which they are installed.

(B) *Locking.* Remotely controlled switches, oil switches, and disconnectors shall be so arranged that they can be secured in the open position or plainly tagged to prevent careless closing while work is being done on equipment controlled by them.

It is important that the control circuit be tagged or provided with a positive disconnecting means near the apparatus to prevent accidental operation of the mechanism.

For switches and disconnectors the accidental opening of which may cause hazard, similar arrangements are desirable for retaining them in closed position.

Locking is recommended rather than blocking wherever parts of equipment are remote from the point of control.

(C) *Air breaks.* Unless a switch operating on a circuit between 750 and 7,500 volts makes an air break, it is recommended that there shall be installed between it and the source of energy supply a suitable air or oil break disconnector or equivalent device having an air or oil gap suitable for the operating voltage of the circuit.

An air break switch or air-break disconnector shall be inserted in each conductor between electrical supply equipment or lines and sources of energy of more than 7,500 volts, if the equipment or lines may have to be worked on without protective grounding while the sources may be alive (for lightning arresters see Order 1191).

(D) *Alinement.* Knife switches shall maintain such alinement under service conditions that they can be closed with a single unhesitating motion.

Order 1175. Where Fuses or Automatic Circuit-Breakers are Required.

All circuit leads to motors, constant-potential generators, transformer primaries, and station auxiliaries, and all outgoing circuits shall be protected from excessive current by suitable fuses or automatic circuit-breakers, except as indicated below.

Fuses and automatic circuit-breakers may be omitted from the following:

(1) A motor-driven generator or rotary converter when the supply leads to such apparatus are already protected by fuses or automatic circuit-breakers.

(2) Ground conductors.

(3) Circuits for field excitation.

(4) Leads of alternating-current generators.

(5) Leads connecting two or more pieces of electrical supply equipment operated as a single unit.

(6) Circuits supplying interconnected three-wire systems of direct-current distribution.

(7) Leads of series transformers.

(8) Leads of potential transformers or other circuits, the opening of which may cause greater hazard to life or property through interruption of service.

Order 1176. Disconnection of Fuses Before Handling.

Fuses in circuits of more than 150 volts to ground or more than 60 amperes shall be arranged in one of the following ways:

(1) So that the fuses are necessarily disconnected from all sources of electrical energy before they can be touched.

(2) So that the fuses can be disconnected from all sources of electrical energy by a suitable switch.

(3) So that the fuses can be conveniently handled by means of insulating handles or portable appliances provided for the purpose.

Exception: Circuits of less than 150 volts to ground and less than 60 amperes capacity are exempted from the provisions of this rule.

The use of insulating gloves and mats is permissible on circuits not exceeding 750 volts.

Order 1177. Arcing or Suddenly Moving Parts.

(A) *Protection from burns.* Fuses and circuit-breakers shall, as far as possible, be so located and shielded that persons will not be burned by their operation.

(B) *Protection against 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 them, shall be guarded or isolated.

Order 1178. Grounding Noncurrent-Carrying Metal Parts.

Exposed noncurrent-carrying parts of switch and fuse cases, levers, and other similar parts to which leakage is liable to occur from live parts, and thereby create a hazard, shall be permanently grounded in accordance with Order 1123.

Exception: Minor parts, such as ferrules of knife switches, which are not liable to become alive, are excepted.

Order 1179. Guarding Live Parts of Switches, Fuses and Automatic Circuit-Breakers.

Switches, fuses, and automatic circuit-breakers shall be isolated or guarded in accordance with Orders 1124 and 1125.

SECTION 118. SWITCHBOARDS

Order 1180. Location and Accessibility.

(A) *General location.* Switchboards shall, where practicable, be so placed that the operator will not be endangered by any live or moving parts of machinery or equipment located near the board.

They shall be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

(B) *Spaces about boards.* The space back of the board shall be kept clear of rubbish and shall not be used for storage.

(C) *Accessibility.* Switchboards shall be accessible to authorized operators from both front and back when the connections are on the back (see Order 1125 for working space), but may be placed against a wall when operating at not more than 750 volts with the wiring entirely on the face.

(D) *Arrangements.* Switchboards shall have all switches so arranged that the points of control are readily accessible to the operator. Instruments, relays, and other devices requiring reading or adjustments shall be so placed that work can be readily performed from the working space.

Order 1181. Material and Illumination.

(A) *Material.* Switchboards shall be made of noncombustible material and be kept free from moisture.

(B) *Illumination.* Sufficient illumination shall be provided both for the front and rear of the switchboard so that the switchboard may be readily operated and instruments conveniently read.

Order 1182. Necessary Equipment.

Switchboards which control generating equipment or outgoing supply circuits shall (except in substations without regular attendance) be equipped with such instruments as are necessary to show operating conditions. (See Order 1155 for ground detectors).

Order 1183. Arrangement and Identification.

Connections, wiring, and equipment of switchboards and panel-boards shall be arranged in an orderly manner, and all switches, fuses, and circuit breakers shall be plainly marked or labeled on fixed parts of equipment or arranged so as to afford ready means for identifying circuits or equipment supplied through them, in accordance with Order 1129.

Order 1184. Spacings and Barriers Against Short-Circuit.

(A) *Bare parts.* Switchboards shall have the number of bare parts at different potentials on any panel reduced to a minimum, and these parts shall be effectively separated. Protection or separation of such parts by suitable barriers is recommended where the voltage exceeds 750.

It is recommended that such parts, including bus bars, should be so located, or provided with such insulating coverings or barriers, that parts at different potentials will not be readily short-circuited by tools or other conducting objects.

(B) *Fuses.* Fuses should be so located as to minimize the danger, in removing or replacing them, of short-circuiting parts at different potentials by the fuses or by the hands of the operator.

Order 1185. Switchboard Grounding.

(A) *Frames.* Switchboard frames and noncurrent-carrying parts shall be permanently grounded under the conditions and with the exceptions noted in Order 1123.

Exception: Parts of switchboards, such as name plates, screws, and similar small parts which are not liable to become alive, except under very unusual circumstances, are not considered as coming under the rule and may be left ungrounded.

(B) *Circuits worked on.* Where protective grounds are occasionally required on circuits for the protection of workmen, a permanent ground connection shall be provided, and also suitable means for effectively and readily connecting the parts being grounded to the ground connection, in accordance with Order 1123C.

Order 1186. Guarding Live Parts on Switchboards.

(A) *Guards.* Live parts of switchboards shall be guarded in accordance with Order 1124.

(B) *Plug-type switchboards.* Plug-type switchboards should, except while connections are being changed, have no current-carrying part exposed on face of boards and, if practicable, they and their plug connectors shall be so arranged where the operating voltage exceeds 150 as to have all current-carrying parts guarded so long as they are alive, even while connections are being changed.

(C) *Exposed parts of more than 7,500 volts.* No switchboard shall have current-carrying parts of more than 7,500 volts exposed (unguarded) unless these parts are effectively isolated by elevation, except at times when occasionally left exposed by removal of covers or entrance into inclosures, such as switch and instrument-transformer cells or compartments which are ordinarily unoccupied by persons. For such parts, if exposed while alive for any purpose (including busses and disconnectors in compartments) working space shall be provided complying with the requirements under Order 1125.

Order 1187. Instrument Cases.

When mounted on switchboards, metal cases of instruments (unless isolated by elevation) operating at more than 750 volts shall be grounded or inclosed in suitable covers, which are either of grounded metal or of insulating material.

SECTION 119. LIGHTNING ARRESTERS

Order 1190. Location.

(A) *Where required.* Lightning arresters should be attached to all ungrounded sides of each system of more than 7,500 volts connected to overhead circuits except circuits in cables with grounded metal sheath.

(B) *Indoors.* Lightning arresters with auxiliaries when installed inside of buildings shall be located well away from all other equipment, passageways, and combustible parts of buildings. When of a type containing oil they should be installed in accordance with Order 1114.

Order 1191. Provisions for Disconnecting.

(A) *Air-break disconnectors.* Lightning arresters on circuits of more than 7,500 volts shall be so arranged, isolated, and equipped that they may be readily disconnected from conductors to which they are connected by air-break manual disconnectors, having air gaps not less than four times the equivalent needle-point sparking distance in air of the operating voltage of the circuit to which the arresters are connected, and never less than 8 inches.

The disconnecting devices may be clamps which can be connected or disconnected while the line is alive.

These disconnecting devices should be installed at a sufficient distance from all parts of the arrester equipment to make it safe to perform maintenance and inspection work on any part of the arrester.

(B) *Working space.* Such disconnectors, unless remotely controlled and operated, shall have the adjacent working spaces required by Order 1125 for disconnectors generally.

Order 1192. Connecting Wires.

Grounding wires shall be run as directly as possible and be of low impedance and ample current capacity (See Section 103 for methods of protective grounding).

Kinks, coils, and sharp bends in the wires between the arresters and the outdoor lines shall be avoided as far as possible.

Order 1193. Grounding Frames and Cases of Lightning Arresters.

All noncurrent-carrying metal parts of arresters shall be grounded, unless effectively isolated by elevation or guarded as required for live parts of the voltage of the circuit to which the arrester is connected, and suitably identified as of that voltage, in accordance with Order 1123.

Order 1194. Guarding Live and Arcing Parts.

(A) *Protection from contact or arcing.* All current-carrying parts of arresters on circuits of more than 750 volts, unless effectively isolated by elevation, shall be adequately guarded to protect persons from inadvertent contact with them, or from injury by arcing, in accordance with Order 1124.

(B) *Making adjustments.* Lightning arresters, unless provided with disconnectors which are always opened before work is done on the arresters, shall be so arranged that necessary adjustments are possible (without approach to current-carrying parts) through the use of permanently grounded mechanisms or suitable insulating appliances. Where charging or adjusting must be done with arresters alive, permanently grounded mechanisms or suitable insulating appliances shall always be provided.

(C) *Insulation of attachments.* All choke coils, gap electrodes, or other attachments, inherent to the lightning protective equipment, shall have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit in the station.

PART 2

RULES FOR THE INSTALLATION AND MAINTENANCE OF OVERHEAD AND UNDERGROUND ELECTRICAL SUPPLY AND COMMUNICATION LINES

SECTION 120. SCOPE OF ORDERS AND GENERAL STATEMENTS

Order 1200. Scope of Orders.

A. *Extent of Application.* The orders in this part of the code, namely orders 1200 to 1299 inclusive, apply to all electrical supply and electrical communication lines in overhead and underground construction, whether operated in connection with public utilities, privately or municipally owned, with industrial establishments, or otherwise.

B. *Not Complete Specifications.* These rules are not complete specifications but are intended to embody the requirements which are most important from the standpoint of safety to employees and the public.

C. *Conformity with Good Practice.* Construction should be made according to accepted good practice for the given local conditions in all particulars not specified in these Orders.

Order 1201. Minimum Requirements.

The orders state the minimum requirements for spacings, clearances, and strength of construction. More ample spacings and clearances or greater strength of construction may be provided if other requirements are not neglected in so doing.

SECTION 121. GENERAL REQUIREMENTS APPLYING TO OVERHEAD AND UNDERGROUND LINES

Order 1210. Design and Construction.

All electrical supply and communication lines and equipment shall be of suitable design and construction for the service and conditions under which they are to be operated.

Order 1211. Installation and Maintenance.

All electrical supply and communication lines and equipment shall be installed and maintained so as to reduce life and fire hazards as far as practicable.

Order 1212. Accessibility.

All parts which must be examined or adjusted during operation shall be arranged so as to be readily accessible to authorized persons by the provision of adequate climbing spaces, working spaces, working facilities, and clearances between conductors.

Order 1213. Inspection and Tests of Lines and Equipment.

A. *When in Service.* 1. Initial Compliance with Rules. Lines and equipment shall comply with these orders upon being placed in service.

2. Inspection. Lines and equipment shall be systematically inspected from time to time.

3. Tests. Lines and equipment shall be subjected, when necessary, to tests which will determine their fitness for service.

4. Record of Defects. Any defects revealed by inspection, if not promptly corrected, shall be recorded.

5. Remedying Defects. Defective lines and equipment shall be put in good order or effectively disconnected.

B. *When Out of Service.* 1. Lines Infrequently Used. Supply lines and equipment infrequently used shall be inspected to see that they are in safe condition for service.

2. Lines Temporarily Out of Service. Lines temporarily out of Service shall be maintained in such condition that a hazard will not be created.

3. Lines Permanently Abandoned. Lines permanently abandoned shall be removed.

Note: Overhead service drops to consumers are often disconnected without removal when the service is discontinued. This is considered good practice when it is undesirable to remove the service drop entirely.

Order 1214. Isolation, Guarding and Marking.

A. *Current-carrying Parts.* To promote safety to the general public and to employees not authorized to approach conductors and other current-carrying parts of electrical supply lines, such parts shall be arranged so as to provide adequate clearance from the ground or other space generally accessible, or shall be provided with guards so as to isolate them effectively from accidental contact by such persons.

B. *Noncurrent-carrying Parts.* Ungrounded metal-sheathed service cables, service conduits, metal fixtures, and similar noncurrent-carrying parts, if located in urban districts and where liable to become charged to more than 300 volts to ground, shall be isolated or guarded so as not to be exposed to accidental contact by unauthorized persons.

As an alternative to isolation or guarding, grounding of certain noncurrent-carrying parts is permitted by Order 1215B and Order 1280A–4.

C. *Marking of Poles Carrying High Voltages.* Section 196.67 of the Wisconsin Statutes provides the following:

"*Warning signs.* (1) Every corporation, company or person constructing, operating or maintaining an electric transmission line with a voltage of six thousand or more between conductors or between conductors and the ground shall place warning signs, not less than four feet nor more than six feet from the ground, upon all poles or other structures supporting such line when within one hundred feet of school grounds; and when within one hundred feet of any place where such line crosses a public highway; and when within any city or village.

(2) Every such sign shall be stenciled on such pole or structure in red or black letters not less than two inches high on a background of white and shall read "Danger—High Voltage." Such stencils shall be furnished by the commission at cost to public utility companies.

(3) Any corporation, company or person violating any of the provisions of this section shall be fined not less than fifty dollars nor more than three hundred dollars for each offense."

Note: This section of the statutes is interpreted to mean distribution as well as transmission line poles, also because of the difficulty of maintaining stenciled signs on a creosoted surface, metal signs with the same wording as specified above may be used on poles which are creosoted farther than 5 feet above the ground line.

Order 1215. Grounding of Circuits and Equipment.

A. *Methods.* The methods to be used for permanent grounding for lightning arresters of supply lines, for circuits, for equipment and for wire raceways are given in the introduction. The methods to be used for grounding of lightning arresters of communication lines are specified in Order 1360.05.

B. *Parts to be Grounded.* In urban districts metal conduits, cable sheaths, and frames, cases, and hangers of equipment shall be permanently grounded.

Exception 1: This order does not apply when such parts are guarded from accidental contact by unauthorized persons.

Exception 2: This order does not apply where such parts are 8 feet or more above the ground.

Exception 3: This order does not apply to metal conduit and cable sheaths inclosing communication conductors, or supply conductors of not more than 300 volts to ground, provided such conduit and sheaths are not exposed to probable contact with circuits of more than 300 volts to ground.

Recommendation: It is recommended that supply cables have the sheath bonded to any conduit extending above the ground surface.

Note: Metal conduit above ground which contains extensions from metal-sheathed underground cable is considered to be sufficiently grounded by the cable sheath, provided such sheath is in good contact with the earth or is connected to a good ground. (For method of grounding see Introduction.)

C. *Use of Ground as Part of Circuit.* In urban districts supply circuits shall not be designed to use the ground normally as the sole conductor for any part of the circuit.

Recommendation: It is recommended that such use be avoided in rural districts.

Order 1216. Arrangement of Switches.

A. *Accessibility.* All switches shall be readily accessible to authorized persons.

B. *Indicating Open or Closed Position.* All switches shall indicate clearly whether they are open or closed.

C. *Uniform Position.* The handles or control mechanism for all switches throughout any system shall have, so far as practicable, the same position when open and a uniformly different position when closed, in order to minimize operating errors. Where it is advisable to depart from this practice, the switches should be marked so as to minimize the liability to mistakes in operation.

SECTION 122. RELATIONS BETWEEN VARIOUS CLASSES OF LINES

Order 1220. Relative Levels.

(A) *Standardization of levels.* The levels at which different classes of conductors are to be located should be standardized where practicable for any given community by agreement of the utilities concerned.

(B) *Relative Levels—Supply and Communication Conductors.* 1. Preferred Levels. Where supply and communication conductors cross each other or are in conflict, or are located on the same poles or towers, the supply conductors shall preferably be carried at the higher level.

Exception: This does not apply to trolley feeders which may be located for convenience approximately at the level of the trolley contact conductor.

2. Minor Extensions. In localities where the practice of placing conductors of communication circuits for public use above supply conductors has been generally established, minor extensions may be made in either system, keeping the conductors in the same relative position. These extensions should not continue beyond a location at which it becomes practicable to change to the arrangement standardized by these orders.

3. Special Construction for Supply Circuits, the Voltage of which does not exceed 550 Volts, and Carrying Power not in Excess of 1,600 Watts when run under Communication Conductors. Where all circuits are owned or operated by one party, or where cooperative consideration determines that the circumstances warrant and the necessary coordinating methods are employed, supply wires carrying a voltage not exceeding 440 volts, where practicable, or in exceptional cases 550 volts between conductors, with transmitted power not in excess of 1,600 watts, when involved in the joint use of poles with communication circuits, may be installed in accordance with Note d (3) of Table 1 in Order 1232A, and Note a of Table 11 in Order 1238A–1, under the following conditions:

(a) That such supply circuits are of wire having a good grade of commercial double-braid weatherproof covering not smaller than No. 8 A. W. G. medium hard-drawn copper or its equivalent in strength, and the construction otherwise conforms with the requirements for supply circuits of the same class.

(b) That the supply circuits be placed on the end and adjacent pins of the bottom cross arm, and that a climbing space of at least 30 inches be maintained up the pole. Special precautions shall be taken to render such circuits conspicuous, such as painting a stripe on the cross arm or using a different form of insulator from the others on the pole line.

(c) That there shall be a vertical clearance of at least 2 feet between the cross arm carrying these supply circuits and the next cross arm above. The other pins on the cross arm carrying the supply circuit may be occupied by com-

munication conductors used in the operation or control of railway or supply apparatus, but not for telegraph or telephone service.

(d) That such supply circuits shall be equipped with fuses and arresters installed in the supply end of the circuit. The fuses shall have a capacity not in excess of twice the maximum operating current value of the circuit they protect, but need not be less than 7 amperes. The arresters shall be designed so as to break down at a voltage of approximately twice the voltage between the wires of the circuit, but which need not be less than 500 volts. Where the supply circuits are alternating current, fuses shall be installed in the secondary side of the supply transformer and shall be such as to open the circuit successfully when the voltage is as great as that of the primary voltage of the transformer.

(C) *Relative Levels—Supply Lines of Different Voltage Classifications (as Classified in Table 11).* 1. At Crossings or Conflicts. Where supply conductors of different voltage classifications cross each other or are in conflict, the higher-voltage lines shall preferably be carried at the higher level.

2. On Poles Used Only by Supply Conductors. Where supply conductors of different voltage classifications are on the same poles, relative levels should be as follows:

(a) Where all circuits are owned by one utility, the conductors of higher voltages should generally be placed above those of lower voltage.

(b) Where different circuits are owned by separate utilities, the circuits of each utility may be grouped together and one group of circuits may be placed above the other group provided that the circuits in each group are located so that those of higher voltage are at the higher levels and that either of the following conditions is met:

(1) A vertical spacing of not less than 4 feet (or 6 feet where required by Table 11, Order 1238A–1), is maintained between the nearest line conductors of the respective utilities (this space to be identified if necessary as a division space.)

(2) Conductors of a lower voltage classification are at a higher level than those of a higher classification only where on the opposite side of the pole.

Order 1221. Avoidance of Conflict and Co-operation to Avoid Hazard.

(A) Two parallel pole lines, either of which carries supply conductors, shall where practicable be so separated

from each other that neither conflicts with the other. If this is impracticable, then the conflicting line or lines shall be built of the grade of construction required by section 124 for a conflicting line or the two lines shall be combined in a single pole line.

(B) Under certain circumstances the proximity of supply lines to communication circuits may produce undesirable effects which may become hazardous. Because of the varied nature of the influence it is difficult to define limits of voltage, parallelism, etc., which will apply in all cases, but by means of cooperation between the supply and communication interests, the companies themselves can doubtless work out the problem in such a way that a serious hazard will not result.

In order to aid in keeping these effects a minimum it is expected that the utilities or parties responsible for the extension or change of electric or communication facilities will cooperate by notifying each other of contemplated extensions; or changes in location, operation, or voltage.

All the utilities or companies affected should determine in conference just what limits of line characteristics, separation and parallelism will be allowed without notification to each other. However in the absence of such an agreement any company before building a line within 500 feet of the line of other companies shall give notice to all companies having lines within the given distance. Such notices will give all companies the opportunity to take such steps for the protection of their property as the law provides.

Order 1222. Joint Use of Poles by Supply and Communication Circuits.

A. *Advantages.* Joint use of poles under suitable conditions and with certain types of circuits offers many advantages and promotes safety.

B. *Cooperative Study.* Joint use involves contractual relations between utilities, consideration of service requirements, and economics as well as safety. It, therefore, requires cooperative study by the utilities concerned.

C. *Conditions Under Which Joint Use is Desirable.* In the case of local or distribution circuits along the same highway or similar right of way, where, under the provisions of section 124 applying to joint use, grade C construction or less would be required, joint use is generally preferable to separate pole lines unless the number of conductors is very large or the character of the circuits makes joint use undesirable.

Where circuits other than those mentioned above are involved, the choice between joint use of poles and separate pole lines shall be determined through cooperative consideration, by the utilities concerned, of all the factors involved, including the character of circuits, the total number and weight of conductors, tree conditions, number and location of branches and service drops, availability of right of way, etc. Where such joint use is mutually agreed upon, it shall be subject to the appropriate grade of construction as specified in section 124. Where such joint use is not employed, separate lines as specified in order 1223 shall be used.

In any event, joint use is preferable to separate lines where it would be impracticable to avoid an overbuilt conflict with separate lines.

Order 1223. Separate Pole Lines.

Where two separate pole lines are to be used, one of which carries supply conductors and the other communication conductors, they shall be separated, if practicable, so that neither conflicts with the other, but if within conflicting distance, they shall be separated as far as practicable.

Order 1224. Approval Necessary for Conflicts and Joint Use of Poles.

In rural districts where in accordance with Section 124, grade A or B construction is required, all projects involving joint use of poles by communication or signal circuits with supply circuits, or conflicts between communication and signal lines with supply lines shall be referred to the Public Service Commission for approval. The request for the approval of such a line must have a statement attached to the effect that all utilities and railroads known to be affected have been notified of the construction or reconstruction.

Note: The Public Service Commission also has other orders, not included in this code, which require certain lines and construction projects to be approved.

SECTION 123. CLEARANCES

The following sections of the Wisconsin Statutes apply to clearances etc. Where the code requires greater clearance than the Statutes the code requirements shall be used.

"**86.16 Electric lines on highways; place of poles; penalty.** (1) Any person, firm or corporation may, with the written consent of the town board, but subject to the approval of the state highway commission, construct and operate telegraph, telephone or electric lines for the purpose of transmitting messages, light or power along or within the limits of any highway.

"(2) All poles used in the construction of such lines shall be set in such manner as not to interfere with the use of such highway by the public nor with the use of the adjoining land by the owner thereof; and all wires shall be not less than eighteen feet above the ground at all crossings, and not less than fourteen feet above the ground at all other places.

"(3) No tree shall be cut, trimmed or the branches thereof cut or broken in the construction or maintenance of any such line without the consent of the owner of the tree.

"(4) Any person erecting any telephone, telegraph, electric light or other pole or stringing any telephone, telegraph, electric light or other wire in violation of the provisions of this section shall forfeit a sum not less than ten nor more than fifty dollars.

"(5) Any person, firm or corporation whose written application for permission to construct such lines within the limits of any highway of any town has been refused, or when such application shall have been on file with the town clerk for twenty days and no action shall have been taken thereon, such applicant may file with such town clerk a notice of appeal to the state highway commission. The town clerk shall thereupon make return of all the papers and action of the board to the state highway commission, and such commission shall proceed to hear and try and determine such appeal on ten days' notice to the town board, and the applicant. The order entered by the commission shall be final."

"**180.17 Transmission lines; privileges; damages.** (1) RIGHT OF WAY FOR. Any domestic corporation organized to furnish telegraph, telephone, service or transmit heat, power or electric current to the public or for public purposes, may, subject to reasonable regulations made by any city or village through which its transmission lines or systems may pass, construct and maintain such lines or systems with all necessary appurtenances in, across or beneath any public highway or bridge or any stream or body of water, or upon any lands of any owner consenting thereto, and for such purposes may acquire lands or the necessary easements; and may connect and operate its lines or system

with other lines or systems devoted to like business, within or without this state, and charge reasonable rates for the transmission and delivery of messages or the furnishing of heat, power or electric light.

"(2) NOT TO OBSTRUCT USE. But no such line or system or any appurtenance thereto shall at any time obstruct or incommode the public use of any highway, bridge, stream or body of water.

"(3) ABANDONED LINES REMOVED. The public service commission after a public hearing as provided in section 196.26, and subject to the right of review as provided in chapter 196, may declare any line to have been abandoned or discontinued, if the facts warrant such finding. Whenever such a finding shall have been made the corporation shall remove such line, and on failure for three months after such finding of abandonment or discontinuance, any person owning land over, through or upon which such line shall pass, may remove the same, or the supervisors of any town within which said lines may be situated, may remove the said lines from the limits of its highways, and such person or supervisors shall be entitled to recover from the company owning the lines the expense for labor involved in removing the property.

"(4) LOCATION OF POLES. In case of dispute as to the location of poles, pipes or conduits, the commissioners appointed in condemnation proceedings under chapter 32 may determine the location. In no case, except where the owner consents, shall poles be set in front of or upon any residence property, or in front of a building occupied for business purposes, unless the commissioners find that the same is necessary and the court may review the finding.

"(5) LIMITATION OF ACTION. The proceedings authorized in chapter 32 shall not be taken nor other action commenced against the corporation in respect to its rights to use or possess lands, unless begun within six years after the commencement of such use or possession.

"(6) TREES PROTECTED, PENALTIES. Any such corporation which shall in any manner destroy, trim or injure any shade or ornamental trees along any such lines or systems, or cause any damage to buildings, fences, crops, live stock or other property, except by the consent of the owner, or after the right so to do has been acquired, shall be liable to the person aggrieved in three times the actual damage sustained, besides costs.

"(7) MUNICIPAL FRANCHISE REQUIRED. No lighting or heating corporation shall have any right hereunder in any city or village until it has obtained a franchise from such city or village.

"**180.18 Wires over railroads.** All wires strung over any steam railroad shall be tied to insulators fastened to double cross-arms attached to a pole at each side of the crossing. The poles if of wood shall not be less than six inches in diameter at the top (if of other materials at least the equivalent strength thereof), set not less than five feet in the ground, securely guyed, and, unless the railroad right of way is over one hundred feet in width, shall be set not more than one hundred feet apart. The cross-arms shall be attached to the poles by machine bolts, and braced by at least one iron brace from each cross-arm to the pole. All wires shall be maintained not less than twenty-five feet above the rails, except street railway trolley wires, which shall be maintained not less than twenty-two feet above the rails.*

"(2) Any person ordered by the public service commission to change its wires so as to conform to this section failing to comply with such order within ten days from the service thereof, shall forfeit twenty-five dollars, and a like forfeiture for every additional ten days of noncompliance with the order, unless a greater length of time to make such change shall be granted."

Order 1230. General.

A. *Application.* This section covers all clearances involving poles and wires. Clearances of lamps from pole surfaces, from spaces accessible to the general public, and height above ground are covered in Order 1286E.

B. *Constant-Current Circuits.* The clearances for constant-current circuits shall be determined on the basis of their nominal full-load voltage.

C. *Metal-Sheathed Supply Cables.* As far as clearances are concerned, permanently grounded continuous metal-sheathed supply cables of all voltages are classified the same as open supply wires of 0 to 750 volts.

D. *Maintenance of Clearances.* When initial wire sags have increased, due to permanent elongation of wires or movement of supporting structures, so that the clearances or separations have materially decreased, slack should be taken up.

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* Note: See first paragraph Section 123.

Order 1231. Horizontal Clearances of Supporting Structures from Other Objects.

Poles, towers, and other supporting structures and their guys and braces shall have the following horizontal clearances from other objects. The clearance shall be measured between the nearest parts of the objects concerned.

A. *From Fire Hydrants.* Not less than 3 feet.

Recommendation: Where conditions permit, a clearance of not less than 4 feet is recommended.

B. *From Street Corners.* Where hydrants are located at street corners, poles and towers should not be set so far from the corners as to make necessary the use of flying taps inaccessible from the poles.

C. *From Curbs.* Not less than 6 inches measured to the street side of the curb if practicable.

D. *From Railroad Tracks.* Where railroad tracks are parallel or crossed by overhead lines, the poles shall, if practicable, be located not less than 12 feet from the nearest track rail.

Exception 1: At sidings a clearance of not less than 7 feet may be allowed, provided sufficient space for a driveway be left where cars are loaded or unloaded.

Exception 2: Supports for overhead trolley contact conductors may be located as near their own track rail as conditions require. If very close, however, permanent screens on cars will be necessary to protect passengers.

Exception 3: Where necessary to provide safe operating conditions which require an uninterrupted view of signals, signs, etc., along tracks, the parties concerned shall cooperate in locating poles to provide the necessary clearance where practicable.

E. *Protection from Fires.* Poles and towers shall be so placed, guarded and maintained as to be exposed as little as practicable to brush, grass, rubbish or building fires.

Order 1232. Vertical Clearance of Wires Above Ground or Rails.

The vertical clearance of all wires above ground in generally accessible places or above rails shall be not less than the following:

TABLE 1

Minimum Vertical Clearance of Wires Above Ground or Rails

(All voltages are between wires unless otherwise stated. Supply wires include trolley feeders)

Nature of ground or rails underneath wires	Guys; messengers; communication span and lightning protection wires; permanently grounded continuous metal sheath cables All voltages	Open supply line wires, arc wires and service drops			Trolley contact conductors and associated span or messenger wires (a)	
		0 to 750 volts	750 to 15,000 volts	15,000 to 50,000 volts	0 to 750 volts to ground	Exceeding 750 volts to ground
WHERE WIRES CROSS OVER						
	Feet	Feet	Feet	Feet	Feet	Feet
Track rails of railroads handling freight cars on top of which men are permitted	b27	b27	b28	30	22	22
Streets, alleys or roads in urban or rural districts	18	18	20	22	18	20
Driveways to residence garages	10	10	20	22	18	20
Spaces or ways accessible to pedestrians only	c14	d15	15	17	e16	e18
WHERE WIRES RUN ALONG						
Streets or alleys in urban districts	f18	18	20	22	18	20
Roads in rural districts	f14	15	18	20	18	20

FOOTNOTES FOR TABLE 1

a. Where subways, tunnels, or bridges require it, less clearances above ground than required by Table 1 may be used locally. The trolley contact conductor should be graded very gradually from the regular construction down to the reduced elevation.

b. This clearance may be reduced to 25 feet where paralleled by trolley contact conductor on the same street or highway.

c. This clearance may be reduced as follows: Feet

(1) For communication conductors of circuits limited to 160 volts to ground and carrying not more than 50 watts 8
(2) For conductors of other communication circuits 10
(3) For guys 8

d. This clearance may be reduced as follows:

(1) Supply wires (except trolley contact wires) limited to 300 volts to ground 12
(2) Supply wires (except trolley contact wires) limited to 150 volts to ground and located at entrances to buildings 10
(3) Where supply circuits of 550 volts or less, with transmitted power of 1,600 watts or less are run along fenced (or otherwise guarded) private rights of way in accordance with the provisions specified in Order 1220, B.3 10

e. Trolley contact conductors for industrial railways when not along or crossing over roadways may be placed at a less height if suitably guarded.

f. No clearance from ground is required for anchor guys not crossing streets, driveways, roads, or pathways nor for anchor guys provided with traffic guards and paralleling sidewalk curbs.

A. *Basic Clearances.* The clearances in Table 1 apply under the following conditions:

Temperature of 60° F., no wind.
Span lengths 0 to 150 feet.
Voltage 0 to 50,000 volts.
Fixed conductor supports.
For other conditions see Order 1232B.

B. *Increased Clearances.* Greater clearances than given in Table 1, Order 1232A shall be provided under the following conditions. The increases required in 1, 2, and 3 below are cumulative where more than one applies.

1. Spans Exceeding 150 Feet.

Exception: Trolley contact conductors are exempted from this rule.

(a) General. For spans exceeding 150 feet the clearance shall be increased by 0.1 foot for each 10 feet of the excess over 150 feet. See (c) below.

(b) At Railroad Crossings. Where the clearance of conductors is determined by the presence of railroad or railway tracks in the span, the increase in clearance may be determined by the following:

Where the distance from the nearer crossing support to the farthest track rail does not exceed 75 feet, no increase is required.

Where this distance exceeds 75 feet, 0.2 for each 10 feet of excess. See (c) below.

(c) Maximum Increase in Clearance. The increase in clearance given by (a) or (b) above need not exceed 2.5 feet provided conductor sags are such that the maximum tension in the conductor does not exceed the specified percentage of its breaking load.

Note: The maximum increase in clearance of 2.5 feet was taken from the National Electrical Safety Code. This maximum increase in clearance is for heavy loading districts only. The maximum increase for light and medium loading districts is more.

2. Voltages Exceeding 50,000. For these voltages the clearances given in Table 1, Order 1232A shall be increased at the rate of 0.5 inch for each 1,000 volts of the excess.

3. Conductors Supported by Suspension-Type Insulators at Crossings over Track Rails. The clearance shall be increased by such an amount that the values specified in Table 1, Order 1232A, will be maintained in case of a broken conductor in either adjoining span, if the conductor is supported as follows:

(a) At one support by suspension-type insulators in a suspended position, and at the other support by insulators which are not free to swing (including semistrain-type insulators).

(b) At one support by strain insulators and at the other support by semistrain-type insulators.

4. Methods of Avoiding this Increase of Clearance. Any of the following construction methods will avoid the necessity for the increase in clearance required by Order 1232, B, 3.

(a) Suspension-type insulators in a suspended position at both supports.

(b) Semistrain-type insulators at both supports.

(c) Arrangement of insulators so that they are restrained from displacement toward the crossing.

C. *Supply Pole Wiring at Underground Risers.* Supply wires connecting to underground systems shall not be run open closer to the ground than is indicated by Table 2:

TABLE 2

Clearance Above Ground For Open Supply Wiring

Voltage		
0 to 750 volts	750 to 15,000 volts	More than 15,000 volts
Feet 14	Feet 16	Feet 18

Order 1233. Wire Crossing Clearances.

The clearance between any two wires crossing each other and carried on different supports shall be not less than the following:

A. *Basic Clearances.* The clearances given in Table 3 below apply under the following conditions:

Temperature of 60° F., no wind.

Where the sum of the distances from the point of intersection of two crossing wires to the nearer supporting structure of each span does not exceed 100 feet.

Where the upper conductor or wire has fixed supports.

Conductors of lines operating at the voltages indicated at the heads of columns should, in general, be installed above those to the left of the table, where a clearance is given in boldface type.

B. *Increased Clearances.* Greater clearances than given in Table 3, Order 1233 A, shall be provided under the following conditions:

The increases required in 1, 2 and 3 below are cumulative where more than one applies.

1. Where the Sum of the Distances from the Nearer Supporting Structure of Each Span to the Point of Intersection Exceeds 100 Feet.

Under this condition the clearances given in Table 3, Order 1233 A, shall be increased by 0.1 foot for each 10 feet

TABLE 3

Wire Crossing Clearances

(All voltages are between wires except for trolley contact wires where voltages are to ground)
(The insertion of a given clearance in italics indicates that in general the lines operating at the voltage named above this clearance should not cross over the lines at the voltage to the left of the clearance in italics)

Nature of wires crossed over	Communication wires	Open supply wires 0 to 750 volts and permanently grounded continuous-metal-sheath supply cables of all voltages		Open supply wires and service drops		Guys, messengers, span wires, lightning protection wires (a)
		Line wires	Service drops	750 to 7,500 volts	7,500 to 50,000 volts	
	Feet	Feet	Feet	Feet	Feet	Feet
Communication, including cables and messengers	b2	c4	2	4	6	b2
Supply cables having permanently grounded continuous metal sheath, all voltages	*4*	2	2	2	4	2
Open supply wires:						
0 to 750 volts	*4*	2	2	2	4	2
750 to 7,500 volts	*4*	*2*	*4*	2	4	4
7,500 to 50,000 volts	*6*	*4*	*6*	*4*	4	4
Trolley Contact conductors	d4	d4	d4	6	6	d4
Guys, messengers, span wires, lightning-protection wires, service drops 0 to 750 volts	b2	2	2	4	4	b2

FOOTNOTES FOR TABLE 3

a. Completely insulated sections of guys attached to supporting structures having no conductor of more than 7,500 volts may have less than this clearance from each other.

b. The clearance of communication conductors and their guy span, and messenger wires from each other in locations where no other classes of conductors are involved may be reduced by mutual consent of the parties concerned, subject to the approval of the regulatory body having jurisdiction, except for fire-alarm wires and wires used in the operation of railroads, or where one set of conductors is for public use and the other used in the operation of supply systems.

c. A clearance of 2 feet may be permitted where the supply conductor is above the communication conductor, provided the crossing is not within 6 feet from any pole concerned in the crossing and the voltage to ground does not exceed 300 volts.

d. Trolley-contact conductors of more than 750 volts should have at least 6 feet clearance. This clearance should also be provided over lower-voltage trolley-contact conductors unless the crossover conductors are beyond reach of a trolley pole leaving the trolley-contact conductor or are suitably protected against damage from trolley poles leaving the trolley-contact conductor.

e. Trolley feeders are exempt from this clearance requirement for trolley-contact conductors if they are of the same nominal voltage and of the same system.

of the excess over 100 feet. This increase need not exceed 2.5 feet when the sag of the upper conductor is such that the maximum stress in that conductor will not exceed the specified percentage of its ultimate stress.

Note: The maximum increase in clearance of 2.5 feet was taken from the National Electrical Safety Code. This maximum increase in clearance is for heavy loading districts only. The maximum increase for light and medium loading districts is more.

2. Voltages Exceeding 50,000. For these voltages the clearances given in Table 3, Order 1233A, shall be increased at the rate of 0.5 inch for each 1,000 volts of the excess.

3. Conductors Supported by Suspension-Type Insulators at Crossings over Communication Wires. For such conductors the clearance shall be increased by such an amount that the values specified in Table 3, Order 1233A, will be maintained in case of a broken conductor in either adjacent span, provided such conductor is supported as follows:

(a) At one support by suspension-type insulators in a suspended position, and at the other support by insulators not free to swing (including semistrain-type insulators).

(b) At one support by a strain insulator, and at the other support by a semistrain-type insulator.

4. Methods of Avoiding this Increase of Clearance. Any of the following construction methods will avoid the necessity for the increase in clearance required by Order 1233, B, 3.

(a) Suspension-type insulators in a suspended position at both supports.

(b) Semistrain-type insulators at both supports.

(c) Arrangement of insulators so that they are restrained from displacement toward the crossing.

Order 1234. Clearances of Conductors of One Line From Other Conductors and Structures.

A. *Clearances from Conductors of Another Line.* The clearance in any direction between any conductor of one line and any conductor of a second and conflicting line shall be not less than the largest value required by 1, 2, or 3 below at 60° F. and no wind.

1. Four feet.

2. The values required by Order 1235, A, 2, (a) (1) or (2) for separation between conductors on the same support.

3. The apparent sag of the conductor having the greater sag, plus 0.2 inch per kilovolt of the highest voltage concerned.

B. *Clearances from Supporting Structures of Another Line.* Conductors of any line passing near a pole or similar supporting structure of a second line without being attached thereto, shall have clearances from any part of such structure not less than the larger value required by either 1 or 2 below at 60° F. and no wind.

1. Three feet if practicable.

2. The values required by Order 1235, A, 2, (a) (1) and (2) for separation between similar conductors on the same support, increased by 1 inch for each 2 feet of the distance from the supporting structure of the second line to the nearest supporting structure of the first line.

The climbing space on the structure of the second line shall in no case be reduced by a conductor of the first line.

C. *Clearances from Buildings.* 1. General. Conductors shall be arranged and maintained so as to hamper and endanger firemen as little as possible in the performance of their duties.

2. Ladder Space. Where buildings exceed three stories (or 50 feet) in height, overhead lines should be arranged where practicable so that a clear space or zone at least 6 feet wide will be left, either adjacent to the building or beginning not over 8 feet from the building to facilitate the raising of ladders where necessary for fire fighting.

Exception: This requirement does not apply where it is the unvarying rule of the local fire departments to exclude the use of ladders in alleys or other restricted places which are generally occupied by supply lines.

3. Open Supply Conductors Attached to Buildings. Where the permanent attachment of open supply conductors of any class to buildings is necessary for an entrance, such conductors shall meet the following requirements:

(a) Conductors of more than 300 volts to ground shall not be carried along or near the surface of the building unless they are guarded or made inaccessible.

(b) Clearance of wires from building surface shall be not less than those required in Table 9, Order 1235 A, 3, (a) for clearance of conductors from pole surfaces.

4. Conductors Passing by or Over Buildings. (a) Minimum Clearances. Unguarded or accessible supply conductors carrying voltages in excess of 300 volts shall not come closer to any building or its attachments (balconies, platforms, etc.) than listed below.

(1) Spans 0 to 150 feet.

TABLE 4

Clearances of Supply Conductors from Buildings

Voltage of supply conductors	Horizontal clearances	Vertical clearance
	Feet	Feet
300 to 7,500	3	8
7,500 to 15,000	8	8
15,000 to 50,000	10	10
Exceeding 50,000	10 plus 0.5 inch per kv. in excess	10 plus 0.5 inch per kv. in excess

Note: See Order 1304.02 b, for lower voltages.

(2) Spans Exceeding 150 Feet.

Where span lengths exceed 150 feet, the increased clearances required by Order 1232, B, 1, shall be provided.

Exception: These increased clearances are not required where the voltage of the supply conductors is from 300 to 7,500 volts.

(b) Crossing Roofs.

Supply conductors exceeding 7,500 volts should not be carried over buildings not concerned in the operation of the utility owning them, if this can be avoided.

When it is necessary to attach wires to the roofs of buildings, the supporting structure shall be of substantial construction. Wherever feasible, wires crossing over buildings shall be supported on structures which are independent of the buildings crossed over.

(c) Guarding of Supply Conductors.

Supply conductors of 300 volts or more shall be properly guarded by grounded conduit, barriers, or otherwise, under the following conditions:

(1) Where the clearances set forth in Table 4, Order 1234, C, 4, (a), (1), can not be obtained.

(2) Where such supply conductors are placed near enough to windows, verandas, fire escapes, or other ordinarily accessible places, to be exposed to contact by persons.

Note: Supply conductors in grounded metal-sheathed cable are considered to be guarded within the meaning of this rule.

D. *Clearances from Bridges.* 1. Clearances of Conductors from Bridges. Supply conductors, not installed in grounded conduit or metal-sheath cable, which pass under, over, or near a bridge shall have clearances therefrom not less than given in Table 5.

TABLE 5

Clearances from Bridges

Operating voltages	Readily accessible portions (other than traveled ways(a)) of any bridge, including wing walls or bridge attachments		From ordinarily inaccessible portions (b) of bridges (other than brick, concrete, or masonry) and from abutments	
	For conductors attached to bridge (c)	For conductors not attached to bridge	For conductors attached to bridge (c)	For conductors not attached to bridge (d)
	Feet	Feet	Feet	Feet
0 to 2,500	3.0	3.0	0.5	3.0
Over 2,500 to 5,000	3.0	3.0	1.0	3.0
Over 5,000 to 7,500	3.0	3.0	3.0	3.0
Over 7,500 to 15,000	5.0	5.0	5.0	5.0
Over 15,000 to 25,000	7.5	7.5	7.5	7.5
Over 25,000 to 35,000	7.5	9.0	7.5	9.0
Over 35,000 to 50,000	7.5	12.0	7.5	12.0

(a) Where over traveled ways on or near bridges the clearances of Order 1232 apply.
(b) Bridge seats of steel bridges carried on masonry, brick, or concrete abutments which require frequent access for inspection shall be considered as readily accessible portions.
(c) Conductors should have clearance not less than given in this column, where practicable.
(d) Conductors should have the clearances given in this column increased as much as practicable.

2. Guarding Trolley Contact Conductors Located Under Bridges. (a) Where Guarding is Required. Guarding is required where the trolley contact conductor is located so that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

(b) Nature of Guarding. Guarding shall consist of a substantial inverted trough of non-conducting material located above the contact conductor, or of other suitable means of preventing contact between the trolley pole and the bridge structure.

Order 1235. Minimum Line-Conductor Clearances and Separations at Supports.

A. *Separation Between Conductors on Pole Lines.* 1. Application of Rule. (a) Multi-Conductor Wires or Cables. Cables, and duplex, triple or paired conductors supported on insulators or messengers, whether single or grouped, are for the purposes of this order considered single conductors even though they may contain individual conductors not of the same phase or polarity.

(b) Conductors Supported by Messengers or Span Wires. Clearances between individual wires or cables supported by the same messenger, or between any group and its supporting messenger, or between a trolley feeder supply conductor, or communication conductor, and their respective supporting span wires, are not subject to the provisions of this rule.

(c) Measurement of Clearances. The clearances and separations stated may be measured from the center of the supporting insulator instead of from the conductor itself.

2. Horizontal Separations between Line Conductors. (a) Fixed Supports. Line conductors attached to fixed supports shall have horizontal separations from each other not less than the larger value required by either (1) or (2) below for the situation concerned.

Exception 1: The pin spacing at buckarm construction may be reduced as specified in Order 1236, F, to provide climbing space.

Exception 2: The pin spacing at bridge fixtures may be reduced as specified in Order 1235, C.

Exception 3: Grades D, E, and N need meet only the requirements of (1) below.

(1) Minimum Horizontal Separation Between Line Conductors of the Same or Different Circuits. Separations shall be not less than given in Table 6.

TABLE 6

Minimum Horizontal Separation at Supports Between Line Conductors of the Same or Different Circuits

Class of circuit	Separation	Notes
Communication conductors	Inches 6	Preferable minimum. Does not apply at conductor transposition points.
	3	Permitted where pin spacings less than 6 inches have been in regular use. Does not apply at conductor transposition points.
Railway feeders. 0 to 750 volts, No. 4/0 or larger	6	
0 to 750 volts, smaller than No. 4/0	12	Where 10 to 12 inch separation has already been established by practice, it may be continued, subject to the provisions of Order 1235, A, 2, (a), (2), for spans having apparent sags not over 3 feet and for voltages not exceeding 7,500.
750 volts to 7,500 volts	12	
Other supply conductors 0 to 7,500 volts	12	
For all conductors of more than 7,500 volts add for each 1,000 volts in excess of 7,500 volts.	0.4	

(2) Separations According to Sags. The separation at the supports of conductors of the same or different circuits of grades A, B, or C shall in no case be less than the values given by the following formulas, at 60° F., without wind. The requirements of Order 1235, A, 2, (a), 1, apply if they give a greater separation than this rule.

For line conductors smaller than No. 2. A. W. G.:

$$\text{Separation} = 0.3 \text{ inch per kilovolt} + 7\sqrt{\frac{S}{3} - 8}.$$

For line conductors of No. 2. A. W. G. or larger:

$$\text{Separation} = 0.3 \text{ inch per kilovolt} + 8\sqrt{\frac{S}{12}}$$

where S is the apparent sag in inches of the conductor having the greater sag, and the separation is in inches.

TABLE 7

Separation in Inches Required for Line Conductors Smaller Than No. 2 A. W. G. with Sags of 36 Inches or More

Voltages	Sag (in inches)						
	36	48	72	96	120	180	240
750	14.0	20.0	28.0	34.5	40.0	50.5	59.5
2,200	14.5	20.5	28.5	35.0	40.5	51.0	60.0
6,600	16.0	22.0	30.0	36.5	41.5	52.5	61.5
13,200	18.0	24.0	32.0	38.5	43.5	54.5	63.5
22,000	20.5	26.5	34.5	41.0	46.0	57.0	66.0
33,000	24.0	29.5	38.0	44.0	49.5	60.5	69.5
44,000	27.0	33.0	41.0	47.5	53.0	63.5	72.5
66,000	----------	39.5	48.0	54.0	59.5	70.5	79.0

TABLE 8

Separation in Inches Required for Line Conductors of Size No. 2 A. W. G. or Larger with Sags of 36 inches or more

Voltages	Sag (in inches)						
	36	48	72	96	120	180	240
750	14.0	16.0	20.0	23.0	25.5	31.0	36.0
2,200	14.5	16.5	20.5	23.5	26.0	31.5	36.5
6,600	16.0	18.0	21.5	24.5	27.5	33.0	38.0
13,200	18.0	20.0	23.5	26.5	29.5	35.0	39.5
22,000	20.5	22.5	26.0	29.0	32.0	37.5	42.5
33,000	24.0	26.0	29.5	32.5	35.0	41.0	45.5
44,000	27.0	29.0	33.0	36.0	38.5	44.0	49.0
66,000	----------	36.0	39.5	42.5	45.0	51.0	55.5

(b) Suspension Insulators not Restrained from Movement. Where suspension insulators are used and are not restrained from movement, the conductor separation shall be increased so that one string of line insulators may swing transversely through an angle of 45° from a vertical position without reducing the values given in (a) above.

3. Clearances in any Direction from Line Conductors to Supports, and to Vertical or Lateral Conductors, Span or Guy Wires, Attached to the Same Support.

(a) Fixed Supports. Clearances shall be not less than given in Table 9.

TABLE 9

Minimum Clearance in Any Direction from Line Conductors to Supports, and to Vertical or Lateral Conductors, Span or Guy Wire, Attached to the Same Support

Clearance of line conductors from—	Communication lines		Supply lines		
			0 to 7,500 volts		Exceeding 7,500 volts add for each 1,000 volts of excess
	In general	On jointly used poles	In general	On jointly used poles	
	Inches	Inches	Inches	Inches	Inches
Vertical and Lateral conductors. All circuits	3	3	3	3	0.25
Span and guy wires attached to same pole. General	3	a 6	6	6	.4
When parallel to line	(b)	(b)	(b)	(b)	.4
Lightning protection wires parallel to line	(b)	(b)	(b)	(b)	.4
Surfaces of cross arms	c 3	c 3	3	3	.25
Surfaces of poles	c 3	c 5	3	d 5	.25

a. If practicable.

b. Clearance shall not be less than the separation required by Table 6 or Order 1235, A, 2, (a) (2) between two line conductors of the voltage concerned.

c. Communication conductors may be attached to supports on the sides or bottoms of cross arms or surfaces of poles if at least 40 inches from any supply line of less than 7,500 volts and at least 60 inches from any supply line of more than 7,500 volts carried on the same pole.

d. This clearance applies only to supply conductors carried on cross arms below communication conductors on joint poles. Where supply conductors are above communication conductors the clearance shall be at least 3 inches.

(b) Suspension Insulators not Restrained From Movement. Where suspension insulators are used and are not restrained from movement, the conductor clearances from surfaces of supports, from span or guy wires, or from vertical or lateral conductors shall be such that the values of clearances required by (a) above will be maintained with an insulator swing of 45° from the vertical position.

4. Conductor Separation—Vertical Racks. Line Conductors or cables may be carried on vertical racks on one side of the pole if all the following conditions are met.

(a) The voltage of conductors shall be not more than 750 volts, except that cables having permanently grounded continuous metal sheath may carry any voltage.

(b) Conductors shall be of the same material or materials.

(c) With a 4 inch vertical separation the spans should average not more than 150 feet. With an 8 or 12 inch separation the span length should not average more than 200 or 225 feet respectively.

(See Table 9, Order 1235, A, 3, for necessary clearances from pole surfaces and Order 1236, G, 1, for method of providing climbing space.)

5. Separation Between Supply Conductors of Different Voltage Classifications on the Same Cross Arm. Supply Conductors of any one voltage classification as given in Table 11, Order 1238, A, 1, may be maintained on the same cross arm with supply lines of the next consecutive voltage classification only under the following conditions:

(a) If they occupy pin positions on opposite sides of the pole.

(b) If in bridge-arm or side-arm construction they are separated by a distance of not less than the climbing space required for the higher voltage concerned and provided for in Order 1236.

(c) If the higher-voltage conductors occupy the outer pin positions and the lower-voltage conductors the inner pin positions.

(d) If series lighting or similar circuits, which are ordinarily dead during periods of work on or above the cross arm concerned, occupy the inner pin position and the lower-voltage conductors occupy the outer pin position.

(e) If the two lines concerned are communication lines used in the operation of supply lines, and supply lines of less than 7,500 volts, and are owned by the same utility, provided they are installed as in (a) or (b) above.

B. *Separation Between Conductors Attached to Buildings.* Separation of wires from each other shall not be less than those required in Table 6, Order 1235, A, 2, (a), (1), for separation of conductors from each other at supports.

Exception: Conductors on vertical racks meeting the requirements of Order 1235, A, 4, may have a separation of 4 inches.

C. *Separation Between Conductors Attached to Bridges.* Supply conductors attached to bridges and supported at frequent intervals may have less separation at supports than required by Order 1235, A, 2, (a), (1), and (2). The separation shall not be less than the clearance between supply conductors and the surfaces of poles or cross arms required by Order 1235, A, 3, (a), or less than the following:

Span Length	Separation Inches
0 to 20 feet	6
20 to 50 feet	9

Order 1236. Climbing Space.

A. *Location and Dimensions.* 1. A climbing space having the horizontal dimensions specified in Order 1236, E, shall be provided past any conductors, cross arms, or other parts.

2. The climbing space need be provided on one side or corner of the pole only.

3. The climbing space shall extend vertically past any conductor or other part between levels above and below the conductor as specified in Order 1236, E, F, G, and I, but may otherwise be shifted from any side or corner of the pole to any other side or corner.

B. *Portions of Supporting Structures in Climbing Space.* Portions of the pole or structure when included in one side or corner of the climbing space at buck or reverse-arm construction are not considered to obstruct the climbing space.

C. *Cross Arm Location Relative to Climbing Space.*

Recommendation: Cross arms should be located on the same side of the pole.

Exception: This recommendation does not apply where double cross arms are used on any pole or where cross arms on any pole are not all parallel.

D. *Location of Supply Apparatus Relative to Climbing Space.* Transformers, regulators, lightning arresters, and switches when located below conductors or other attachments shall be mounted outside of the climbing space.

E. *Climbing Space through Conductors On Cross Arms.* 1. Conductors of Same Voltage Classification on Same Cross Arm. Climbing space between conductors shall be of the horizontal dimensions specified in Table 10, (Order 1236, E, 3), and shall be provided both along and across the line, and shall be projected vertically not less than 4 feet above and below the limiting conductors. Where communication conductors are above supply conductors of more than 7,500 volts, the climbing space shall be projected vertically at least 6 feet above the highest supply conductor.

Exception: This Order does not apply if it is the unvarying practice of the employers concerned to prohibit employees from ascending beyond the conductors of the given line, unless the line is killed.

2. Conductors of Different Voltage Classifications on the Same Cross Arm. The climbing space shall be that required by Table 10, (Order 1236, E, 3) for the highest voltage of any conductor bounding the climbing space.

3. Horizontal Climbing Space Dimensions.

TABLE 10

Minimum Horizontal Dimensions of Climbing Space

Character of conductors adjacent to climbing space	Voltage of conductors		Horizontal dimensions of climbing space (inches)			
			On poles used solely by—		On jointly used poles	
	To ground	Between wires	Communication conductors	Supply conductors	Supply conductors above communication conductors	Communication conductors above supply conductors a
Communication conductors	0 to 150	----------	No requirement	----------	(b)	No requirement
	Exceeding 150	----------	24 recommended	----------	(b)	24 recommended
Supply conductors.	Less than 300	----------	----------	24	24	30
	300 to	7,500	----------	30	30	30
		7,500 to 15,000	----------	36	36	36
		Exceeding 15,000		More than c 36	More than c 36	More than c 36

a. This relation of levels is not, in general, desirable and should be avoided.
b. The climbing space shall be the same as required for the supply conductors immediately above.
c. Where practicable. Attention is called to the operating requirements of Order 1422.

F. *Climbing Space on Buckarm Construction.* The full width of climbing space shall be maintained on buckarm

construction and shall extend vertically in the same position at least 4 feet (or 6 feet where required by Order 1236, E, 1), above and below any limiting conductor.

Method of providing Climbing Space on Buckarm Construction. With circuits of less than 7,500 volts and span lengths not exceeding 150 feet and sags not exceeding 15 inches for wires of No. 2 and larger sizes, or 30 inches for wires smaller than No. 2, a six-pin cross arm having pin spacing of 14½ inches may be used to provide a 30-inch climbing space on one corner of a junction pole by omitting the pole pins on all arms, and inserting pins midway between the remaining pins so as to give a spacing of 7¼ inches, provided that each conductor on the end of every arm is tied to the same side of its insulator, and that the spacing on the next pole is not less than 14½ inches.

G. *Climbing Space for Longitudinal Runs.* 1. General. The full width of climbing space shall be provided past longitudinal runs and shall extend vertically in the same position from 4 feet below the run to a point 4 feet above (or 6 feet where required by Order 1236, E, 1). The width of climbing space shall be measured from the longitudinal run concerned.

Exception: If a supply longitudinal run is placed on the side or corner of the pole where climbing space is provided, the width of climbing space shall be measured horizontally from the center of the pole to the nearest supply conductors on cross arms, under the following conditions:

Where the longitudinal run consists of open supply conductors carrying not more than 750 volts or of permanently grounded continuous metal-sheathed supply cable carrying any voltage, and is supported close to the pole as by brackets, racks, or pins close to the pole, and

Where the nearest supply conductors on cross arms are parallel to and on the same side of the pole as the longitudinal run and within 4 feet above or below the run.

2. Protection of Longitudinal Runs. If a longitudinal run is located between points 2 feet and 6 feet below supply line conductors carried on cross arms, it shall be protected by a suitable guard arm securely fastened to the pole, or by substantial insulating conduit. Such protection shall extend to the following distances from the pole center:

	Inches
Longitudinal runs in general	20
Longitudinal runs of grounded metal-sheath cable uninsulated from metal supports attached to the pole	24

H. *Climbing Space Past Vertical Conductors.* Vertical runs incased in suitable conduit or other protective covering and securely attached to the surface of the pole or structure are not considered to obstruct the climbing space.

I. *Climbing Space near Ridge-Pin Conductors.* The climbing space specified in Order 1236, E, 3, shall be provided above the top cross arm and past the ridge-pin conductor.

Exception: Where a single cross arm carrying only two conductors is mounted so that the conductors are 2 feet below a single ridge-pin conductor, the climbing space specified in Order 1236, E, 3, shall be carried up to the ridge-pin conductor, but need not be carried past it.

Order 1237. Lateral Working Space.

A. *Location of Working Spaces.* Working spaces shall be provided on the climbing face of the pole at each side of the climbing space.

B. *Dimensions of Working Spaces.* 1. Along the Cross Arm. The working space shall extend from the climbing space to the outmost pin position on the cross arm.

2. Perpendicular to the Cross Arm. The working space shall have the same dimension as the climbing space (see Order 1236, E). This dimension shall be measured from the face of the cross arm.

3. Vertically. The working space shall have a height not less than that required by Order 1238 for the vertical separation of line conductors carried at different levels on the same support.

C. *Location of Vertical and Lateral Conductors Relative to Working Spaces.* The working spaces shall not be obstructed by vertical or lateral conductors. Such conductors shall be located on the opposite side of the pole from the climbing side or on the climbing side of the pole at a distance from the cross arms at least as great as the width of climbing space required for the highest-voltage conductors concerned. Vertical conductors inclosed in suitable conduit may be attached on the climbing side of the pole.

D. *Location of Buck Arms Relative to Working Spaces.* Buck arms may be used under any of the following conditions, provided the climbing space is maintained. Climbing space may be obtained as in Order 1236, F.

1. Standard Height of Working Space. Lateral working space of the height required by Table 11, (Order 1238, A, 1) may be provided between the buck arms and adjacent

line arms to which conductors on the buck arms are not attached.

Method of meeting requirements. This may be accomplished by increasing the spacing between the line cross arm gains.

2. Reduced Height of Working Space. Where no circuits exceeding 7,500 volts between conductors are involved, and the clearances of Orders 1235, A, 2, (a), (1) and (2) are maintained, buck arms may be placed between line arms having normal spacing, even though such buck arms obstruct the normal working space; provided that a working space of not less than 18 inches in height is maintained either above or below each line arm and each buck arm.

Order 1238. Vertical Separation Between Line Conductors, Cables, and Equipment Located at Different Levels on the Same Pole or Structure.

All line conductors, cables, or equipment located at different levels on the same pole or structure shall have the vertical separations set forth below.

A. *Vertical Separations Between Horizontal Cross Arms.* Cross arms supporting line conductors shall be spaced in accordance with Table 11.

1. Basic Separations. The separations given in the following table are for cross arms carrying conductors of 0 to 50,000 volts attached to fixed supports.

2. Increased Separations for Voltages Exceeding 50,000. For voltages greater than 50,000, the clearances of Table 11 shall be increased at the rate of 0.4 inch per 1,000 volts of the excess.

B. *Vertical Separation Between Line Conductors on Horizontal Cross Arms.* Where line conductors are supported on horizontal cross arms spaced as required in Order 1238, A the vertical separation between such conductors shall be not less than the following:

1. Where Conductors on the Cross Arm are of the Same Voltage Classification. Under these conditions, the vertical separation required by Table 11 may be reduced as follows:

Where cross arm separation required by Table 11 is	Separation between conductors may be reduced to
2 feet	16 inches
4 feet	40 inches
6 feet	60 inches

TABLE 11

Vertical Separation of Cross Arms Carrying Conductors

Conductors usually at lower levels	Supply conductors, preferably at higher levels				
	0 to 750 volts and permanently grounded continuous metal-sheath cables of all voltages	750 to 7,500 volts	7,500 to 15,000 volts	15,000 to 50,000 volts	
				Same utility	Different utilities
Communication conductors:					
General	a b 4	4	6	----------	6
Used in operation of supply lines	2	c 2	4	4	6
Supply conductors: 0 to 750 volts	2	d 2	4	4	6
750 volts to 7,500 volts	----------	d 2	4	4	6
7,500 volts to 15,000 volts— If worked on alive with long-handled tools, and adjacent circuits are neither killed nor covered with shields or protectors	----------	----------	4	4	6
If not worked on alive except when adjacent circuits (either above or below) are killed or covered by shields or protectors, or by the use of long-handled tools not requiring linemen to go between live wires			2	e 4	e 4
Exceeding 15,000 volts, but not exceeding 50,000 volts				e 4	e 4

a. When supply circuits of 550 volts or less, with transmitted power of 1,600 watts or less, are run below communication circuits in accordance with Order 1220, B, 3 the clearance may be reduced to 2 feet.

b. In localities where the practice has been established of placing on jointly used poles, cross arms carrying supply circuits of less than 300 volts to ground and cross arms carrying communication circuits at a vertical separation less than specified in the table, such existing construction may be continued until the said poles are replaced provided that—

The minimum separation between existing cross arms is not less than 2 feet, and that—

Extensions to the existing construction shall conform to the clearance requirements specified in Table 11.

When communication conductors are all in cable, a supply cross arm carrying only wires of not more than 300 volts to ground may be placed at not less than 2 feet above the point of attachment of the cable to the pole provided that—

The nearest supply wire on such cross arm shall be at least 30 inches horizontally from the center of the pole. and that—

The cable be placed so as not otherwise to obstruct the climbing space.

c. This shall be increased to 4 feet when the communication conductors are carried above supply conductors unless the communication-line conductor size is that required for grade C supply lines.

d. Where conductors are operated by different utilities, a minimum vertical spacing of 4 feet is recommended

e. These values do not apply to adjacent cross arms carrying phases of the same circuit or circuits.

2. Where Conductors of Different Voltage Classifications are on Same Cross Arm. Under these conditions, the vertical separation between conductors on adjacent cross arms shall be that required by Table 11 (Order 1238 A, 1) above for the highest voltage classification concerned.

3. Conductors of Different Sags on Same Support. (a) Variation in Clearance. Line conductors supported at different levels on the same structure and strung to different sags shall have vertical spacings at the supporting structures so adjusted that the minimum spacing at any point in the span, at 60° F. with no wind, shall not be reduced

more than 25 per cent from that required at the supports by Orders 1235, A, 2, (a), (1) and (2) and this rule.

(b) Readjustment of Sags. Sags should be readjusted when necessary to accomplish the foregoing, but not reduced sufficiently to conflict with the requirements of Order 1261, F, 4. In cases where conductors of different sizes are strung to the same sag for the sake of appearance or to maintain unreduced clearance throughout storms, the chosen sag should be such as will keep the smallest conductor involved in compliance with the sag requirements of Order 1261, F, 4.

C. *Separation in Any Direction.* The separation in any direction between conductors of the same or different voltage classification when carried on the same structure, but on cross arms which are not horizontal, shall not be less than the values given in Table 11 (Order 1238, A, 1 and 2) for vertical separation.

The separation in any direction shall not in any case be less than the horizontal separation specified in Order 1235, A, 2, (a), (1) and (2).

D. *Vertical Separation for Line Conductors Not Carried on Cross Arms.* The vertical separation between conductors not carried on cross arms shall be the same as required in Order 1238, A, 1 and 2 for cross arms.

Exception: Conductors on vertical racks may have a vertical separation of 4 inches under the conditions specified in Order 1235, A, 4.

E. *Vertical Separation Between Conductors and Noncurrent-Carrying Metal Parts of Equipment.* For the purpose of measuring these separations metal supports for conductors are considered as noncurrent-carrying metal parts of equipment.

1. Between Supply Conductors and Communication Equipment. The vertical separations specified in Table 11 (Order 1238, A, 1) as 4 feet, may be reduced to 40 inches where the voltage of the supply conductors does not exceed 750, or where supply conductors of any voltage are in permanently grounded continuous-metal-sheath cable.

2. Between Communication Conductors and Supply Equipment. The vertical separations specified in Table 11 (Order 1238, A, 1) as 4 and 6 feet, may be reduced to 40 inches and 60 inches, respectively.

3. Between Supply and Communication Equipment.

(a) General. The vertical separation specified in Table 11 (Order 1238, A, 1) as 4 and 6 feet, may be reduced to 40 inches and 60 inches, respectively.

(b) Special Separations for Span Wires or Brackets. Span wires or brackets for lamps or trolley contact conductors shall have at least the vertical separation from communication equipment set forth below.

From cross arms carrying communication conductors	2 feet
From messenger wires carrying communication cables	1 foot
From terminal box of communication cables, if practicable	1 foot

Exception: Where it is not practicable to obtain a clearance of 1 foot from terminal boxes of communication cables, all metal parts of terminals shall have the greatest practicable separation from fixtures or span wires, including all supporting screws and bolts of both attachments.

4. Supply Cross-Arm Braces Considered as Equipment. Where supply cross-arm braces are less than 1 inch from transformer cases or hangers, the vertical separation from communication equipment shall be measured from the nearest part of this supply equipment, including the cross-arm brace.

F. *Vertical Separation Between Communication Conductors Carried at Different Levels on Railroad Crossing Poles.* At crossings of communication lines over railroads, the vertical clearance between conductors supported on the same pole or structure and at different levels shall in no case be less than 12 inches and preferably shall be 24 inches.

Exception: Transpositions are excepted.

Order 1239. Clearances of Vertical and Lateral Conductors from Other Wires and Surfaces on the Same Support.

Vertical and lateral conductors shall have the clearances and separations required by this rule from other conductors, wires, or surfaces on the same support.

Exception 1: This Order does not prohibit the placing of supply circuits of the same or next voltage classification in the same iron pipe, if each circuit or set of wires be inclosed in a metal sheath.

Exception 2: This Order does not prohibit the placing of paired communication conductors in rings attached directly to the pole or to suspension strand.

A. *Location of Vertical or Lateral Conductors Relative to Climbing Spaces, Working Spaces, and Pole Steps.* Vertical or lateral conductors shall be located so that they do not obstruct climbing spaces, or lateral working spaces between line conductors at different levels or interfere with the safe use of existing pole steps.

Exception 1: This Order does not apply to portions of the pole which workmen do not ascend while the conductors in question are alive.

Exception 2: This Order does not apply to vertical runs incased in suitable conduit or other protective covering. (See Order 1236, H.)

B. *Conductors not in Conduit.* Conductors not incased in conduit shall have the same clearances from conduits as from other surfaces of structures.

C. *Mechanical Protection near Ground.* Where within 8 feet from the ground, all vertical conductors, cables, and grounding wires shall be protected by a covering which gives suitable mechanical protection. For grounding wires from lightning arresters, the protective coverings specified above shall be of wood molding, or other insulating material giving equivalent protection.

Exception 1: This covering may be omitted for armored cables or cables installed in a grounded metal conduit.

Exception 2: This covering may be omitted for lead-sheathed cables in rural districts.

Exception 3: This covering may be omitted for communication circuits on private fenced rights of way in the case of conductors or cables from underground systems.

Exception 4: This covering may be omitted for grounding wires having triple-braid weather-proof covering, in rural districts or where such grounding wire is one of a number of grounding wires used to provide multiple grounds.

D. *Requirements for Vertical and Lateral Supply Conductors on Supply Line Poles or Within Supply Space on Jointly Used Poles.* 1. General Clearances. In general, clearances shall be not less than the values specified in Table 12.

TABLE 12

Clearance of vertical and lateral conductors	Clearances (in inches) for highest voltage concerned in the clearance	
	0 to 7,500 volts	Exceeding 7,500 volts (add the following for each 1,000 in excess)
From surfaces of supports	3	0.25
From span, guy or messenger wires	6	.4
From line conductors rigidly supported on fixed supports, such conductors being of— All circuits	3	.25
From line conductors not rigidly supported on fixed supports	(a)	(a)

a. The clearances shall be increased beyond the values given above from line conductors on fixed supports (See Order 1235, A, 2, (b), and 3, (b)).

2. Special Cases. The following apply only to portions of a pole which workmen ascend while the conductors in question are alive.

(a) Vertical conductors of not more than 7,500 volts shall clear pole centers by not less than 15 inches for a distance of not less than 4 feet above and below any open supply line conductors which are not of more than 7,500 volts when the latter are carried on or within 4 feet from the pole. If the vertical conductors are of more than 7,500 volts, this clearance shall be at least 20 inches. If the supply conductors are of more than 7,500 volts, the clearance from the pole center shall apply for a distance of not less than 6 feet above and below, except as noted in (b) and (c), below.

(b) Vertical and lateral supply conductors, including grounding wires, which are inclosed in insulated conduit, or in metal conduit or cable protected by an insulating covering (or wood molding if wire be used having triple-braid weather-proof covering), whenever within 4 feet of open supply wires of less than 7,500 volts or within 6 feet from open supply wires of more than 7,500 volts may have less than the clearances specified in (a) above, except as provided in (c) below.

(c) Vertical and lateral conductors of less than 7,500 volts when on poles used only for supply lines may be run on the street side of the pole in multiple-conductor cable having suitable substantial insulating covering, if such cable is held taut on standard insulators supported on pins and brackets and is arranged so that the cable shall be held at a distance of approximately 5 inches from the surface of the pole, or from any pole step.

E. *Requirements for Vertical and Lateral Communication Conductors on Communication Line Poles or Within the Communication Space on Joint Poles.* 1. Clearances From Wires. The clearances and separations of vertical and lateral conductors from other conductors (except those in the same ring run) and from guy, span, or messenger wires shall be 3 inches.

2. Clearances From Pole and Cross Arm Surfaces. Vertical and lateral communication conductors may be attached directly to the pole or cross arm by means of rings, knobs, or brackets provided that they are rubber-insulated paired conductors and that in the case of joint poles, the clearances from open supply lines required by Table 11 (Order 1238, A, 1) are observed.

F. *Requirements for Vertical Supply Conductors Passing Through Communication Space on Jointly Used Poles.* Vertical supply conductors, including grounding wires, which pass through communication line space on joint poles shall be installed as follows:

1. Metal-Sheathed Supply Cables. Metal-sheathed supply cables shall be covered as follows:

(a) Extent of Covering. Covering shall extend from the lowest points of such cables up to the following distances above the highest communication conductors.

Kind of supply cable	Supply voltage	Distance
		Inches
Metal-sheathed	0 to 7,500	a40
	Over 7,500	60
Permanently grounded continuous-metal-sheathed	All voltages	40

a. This distance may be reduced to 24 inches for supply cables less than 300 volts to ground where a vertical joint-use separation of 2 feet exists or is permissible. (See footnote b to Table 11 for conditions under which the separation is permitted.)

(b) Nature of Covering. The covering shall consist of wood molding or other suitable insulating material at points higher than 8 feet above the ground.

Exception 1: Iron pipe may be used without insulating covering at points more than 6 feet below the lowest communication wire, or railway feeder or attachment.

Exception 2: Iron pipe may be used throughout if covered with wood molding or other suitable insulating covering from a point 6 feet below the lowest communication wire or railway feeder or attachment to a point 40 inches or 60 inches above the highest communication wire, depending on the supply voltage.

2. Supply Conductors. Supply conductors shall be installed in one of the following ways:

(a) In Conduit. Conductors of all voltages may be inclosed in the same way and to the same extent as required in 1 above for metal-sheathed cables.

(b) On Pins and Insulators. Vertical and lateral conductors of street-lighting circuits and service leads of less than 750 volts may be run on the street side of the pole in multiple-conductor cable having suitable substantial insulating covering if such cable is held taut on standard insulators supported on pins or brackets and arranged so that the cable shall be held at a distance of approximately 5 inches away from the surface of the pole or from any pole steps.

3. Supply Grounding Wires. Supply grounding wires shall be covered with wood molding or other suitable insulating covering to the extent required for metal-sheathed cables in 1 above, the "voltage" of the grounding wire being taken as the voltage of the supply circuit with which it is associated.

4. Separation From Through Bolts. Vertical runs of supply conductors shall be separated from the ends of through bolts associated with communication line equipment by one-eighth of the circumference of the pole where practicable, but in no case less than 2 inches.

G. *Requirements for Vertical Communication Conductors Passing Through Supply Space on Jointly Used Poles.* All vertical runs of communication conductors passing through supply space shall be installed as follows:

1. Metal-Sheathed Communication Cables. Metal-sheathed communication cables shall be covered with wood molding or other suitable insulating covering from a point not more than 8 feet above the ground to the following points above the highest supply conductor.

Nature of supply circuit	Voltage of supply circuit	Distance
		Inches
Permanently grounded continuous-metal-sheathed cable	All voltages	40
Open wire and other cable	0 to 7,500	a40
Open wire and other cable	Exceeding 7,500	60

a. This distance may be reduced to 24 inches for supply voltages less than 300 volts to ground where a vertical joint-use separation of 2 feet exists or is permissible. (See footnote b to Table 11 for conditions under which this separation is permitted.)

2. Communication Conductors. Vertical and lateral runs of rubber-insulated paired conductors shall be covered with wood molding or other suitable insulating covering when within 48 or 72 inches from supply conductors of 7,500 volts or less, or more than 7,500 volts, respectively.

3. Communication Grounding Wires. Grounding wires of communication lines shall be covered with wood molding or other suitable insulating covering to the extent required for metal-sheathed cables in 1 above.

4. Separation From Through Bolts. Vertical runs of communication conductors shall be separated from the ends of through bolts associated with supply-line equipment by one-eighth of the circumference of the pole where practicable, but in no case less than 2 inches.

SECTION 124. GRADES OF CONSTRUCTION

Order 1240. General.

For the purposes of section 126, "Strength requirements," and section 127, "Line insulators," conductors and their supporting structures are classified under the grades specified in this section on the basis of the relative hazard existing.

Order 1241. Application of Grades of Construction to Different Situations.

A. *Supply Cables.* For the purpose of these rules supply cables are divided into two classes as follows:

1. Specially Installed Cables. In this class are included metal-sheathed supply cables installed in accordance with Order 1261, G, 1.

Note: Such cables are sometimes permitted to have a lower grade of construction than open-wire supply conductors of the same voltage.

2. Other Cables. In this class are included all other supply cables.

Note: Such cables are required to have the same grade of construction as open-wire supply conductors of the same voltage.

B. *Two or More Conditions.* In any case where two or more conditions affecting the grade of construction exist, the grade of construction used shall be the highest one required by any of the conditions.

C. *Order of Grades.* For supply and communication conductors and supporting structures, the relative order of grades is A, B, C, and N, grade A being the highest. Where grades D, E, and N are specified for communication lines, grade D is the highest.

Note: Grades D and E can not be directly compared with the series A, B, and C, but Order 1241, D, 3, (c) provides for cases where these two conditions are present.

D. *At Crossings.* 1. Grade of Upper Line. Conductors and supporting structures of a line crossing over another line shall have the grade of construction specified in Orders 1241, D, 3; 1242, and 1243.

2. Grade of Lower Line. Conductors and supporting structures of a line crossing under another line need only have the grades of construction which would be required if the line at the higher level were not there.

3. Multiple Crossings. (a) Where a Line Crosses in One Span Over Two Other Lines.

The grade of construction of the uppermost line shall be not less than the highest grade which would be required of either one of the lower lines if it crossed the other lower line.

Example: If a 2,300-volt line crosses in the same span over a communication line and a direct-current trolley contact conductor of more than 750 volts, the 2,300-volt line is required to comply with grade A construction at the crossing.

This is a double crossing and introduces a greater hazard than where the upper supply line crosses the communication line only.

(b) Where One Line Crosses Over a Span in Another Line, Which Span is in Turn Involved in a Second Crossing. The grade of construction for the highest line shall be not less than that required for the next lower line.

Exception: This requirement does not apply when the two upper lines are of such a nature and have such circuit protection that the danger of causing a break in the lower of these two lines by mechanical or electrical contact is eliminated.

(c) Where Communication Conductors Cross Over Supply Conductors and Railroad Tracks in the Same Span. The grades of construction shall be in accordance with Table 13.

TABLE 13

When crossing over—	Communication conductor grades	
	Major lines	Minor lines
Main tracks and supply line of 0 to 750 volts	D	D
Main tracks and supply line exceeding 750 volts	A	A
Minor tracks and supply line of 0 to 750 volts	E	E
Minor tracks and supply line of 750 to 7,500 volts	B	B
Minor tracks and supply line exceeding 7,500 volts	A	B

Recommendation: It is recommended that the placing of communication conductors above supply conductors at crossings, conflicts, or on jointly used poles be avoided unless the supply conductors are trolley contact conductors and their associated feeders.

E. *Conflicts.* 1. How Determined. Where two lines are adjacent (except at crossing spans) the distance between them and the relative heights above ground of poles and of conductors on each line determine whether conflict exists, and, if so, whether the conflict is a structure conflict (see Definition) or a conductor conflict (see Definition), or both.

2. Conductor Conflict. At conductor conflicts the grade of construction of the conflicting conductor shall be as required by Orders 1241, D, 3, and 1242.

3. Structure Conflict. At structure conflicts, the grade of construction of the conflicting structure shall be as required by Order 1243.

Order 1242. Grades of Construction for Conductors.

The grades of construction required for conductors of all classes in different situations are given in Tables 14 and 15. For the purpose of these tables certain classes of circuits are treated as follows:

A. *Status of Constant-Current Circuits.* In determining grades of construction where constant-current circuits are involved with communication circuits and are not in specially installed cable, the constant-current circuits shall be considered on the basis of their current rating. In all other cases constant-current circuits shall be considered on the basis of their nominal full-load voltage.

B. *Status of Railway Feeders and Trolley Contact Conductors.* In determining grades of construction where railway feeders and trolley contact conductors are involved they shall be considered as other supply conductors of the same voltage.

Exception: Direct-current trolley circuits exceeding 750 volts to ground shall have grade A construction where crossing over, conflicting with, or on joint poles with and above major communication circuits, and grade B where similarly situated with respect to minor communication circuits.

C. *Status of Communication Circuits Used Exclusively in the Operation of Supply Lines.* In determining grades of construction where communication circuits used exclusively in the operation of supply lines are concerned, they shall be considered as ordinary communication circuits when run as such (see Order 1288, C) and as supply circuits when run as such. (See Order 1288, D.)

Exception: Communication circuits located below supply circuits with which they are used shall not require such supply circuits to meet any rules for grade of construction other than that the sizes of such supply conductors shall not be less than required for grade C (see Order 1261, F, 2).

D. *Status of Fire-Alarm Conductors.* In determining grades of construction where fire-alarm conductors are concerned, they shall be considered as other communication circuits.

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TABLE 14

Grades of Construction for Supply Conductors Alone, at Crossings, at Conflicts, or on Same Poles With Other Conductors

Supply Conductors at higher levels (a) / Conductors, tracks, and rights of way, at lower levels		Constant—potential supply conductors other than D. C. railway feeders													Constant-Current supply conductors						Direct-Current railway feeders				Communication conductors used exclusively in the operation of and run as supply lines	
		0 to 750 volts(b)		750 to 5000 volts(c)			5000 to 7500 volts(d)				Exceeding 7500 volts(e)				0 to 7.5 amperes		7.5–10 amperes		Exceeding 10 amps.		0 to 750 volts		Exceeding 750 volts			
		Urban	Rural	Urban		Rural	Urban		Rural		Urban		Rural													
		Open or Cable	Open or Cable	Open	Cable	Open or Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable
Lines on fenced rights of way		N	N	fN	N	N	fN	N	N	N	fN	fN	N	N	B, C, or N. See Order 1242,A.						B, C, or N. See Order 1242,B				C or N. See Order 1242, C	
Lines not on fenced rights of way		N	N	C	N	N	C	N	N	N	B	C	N	N												
Railroad tracks	Main	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	Minor	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Street-railway tracks having no overhead contact conductor		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Constant—potential supply conductors: 0 to 750 volts(b)	Open	N	N	C	N	N	C	N	N	N	B	C	gC	N	B, C, or N. See Order 1242, A						B, C, or N. See Order 1242, B				B, C, or N. See Order 1242, C	
	Cable	N	N	C	N	N	C	N	N	N	B	C	gC	N												
750 to 5000 volts(c)	Open	hC	N	C	C	N	C	C	N	N	B	C	N	N												
	Cable	N	N	C	N	N	C	N	N	N	B	C	N	N												
5000 to 7500 volts(d)	Open	hC	N	C	C	N	C	C	N	N	B	C	N	N												
	Cable	N	N	C	N	N	C	N	N	N	B	C	N	N												
Exceeding 7500 v.(e)	Open	hB	hC	B	B	N	B	B	N	N	B	C	N	N												
	Cable	hC	N	C	N	N	C	N	N	N	B	C	N	N												
Constant-current supply conductors open or cable		B, C, or N See Order 1242 A.													B, C, or N. See Order 1242, A						B, C, or N. See Orders 1242, A, B				B, C, or N. See Orders 1242, A, C.	
Direct-current railway feeders open or cable		B, C, or N See Order 1242, B													B, C, or N. See Orders 1242, A and B						B, C, or N. See Order 1242, B				B, C, or N See 1242, B, C.	
Trolley contact conductors A.C. or D.C.		B, C, or N. See Order 1242, B.													B, C, or N. See Orders 1242, A and B						B, C ,or N. See Order 1242, B				B, C, or N. See Orders 1242, B, C.	
Communication conductors, open or cable, used exclusively in the operation of supply lines		A, B, C, or N. See Order 1242, C.													A, B, C, or N. See Orders 1242, A and C						A, B, C, or N. See Orders 1242B, C				B, C, or N. See Order 1242, C	
Communication conductors urban or rural open or cable	Major (i)	N	N	C	C	C	B	C	B	C	A	C	A	C	C	C or N See 1242A	B	C or N See 1242A	A	C or N See 1242A	N	N	A	C	B, C, or N. See Order 1242, C	
	Minor (i)	N	N	C	C	C	C	C	C	C	B	C	B	C	C		C		B		N	N	B	C		

(a) The words "open" and "cable" appearing in the column headings have the following meanings as applied to supply conductors: "Cable" means the specially installed cables described in Order 1241, A, 1. "Open" means open wire and also supply cables not "specially installed."
(b) Voltages to neutral or ground of 0 to 440 volts.
(c) Voltages to neutral or ground of 440 to 2,900 volts.
(d) Voltages to neutral or ground of 2,900 to 4,400 volts.
(e) Voltages to neutral or ground exceeding 4,400 volts.

(f) Where lines are located so that they can fall outside the fenced right of way into urban districts the construction shall comply with the grades specified for lines not on fenced rights of way for corresponding voltage.
(g) Grade N if crossing over or conflicting with supply services.
(h) If the wires are service drops they may have grade N sizes and sags as set forth in Tables 32 and 33 (Order 1263, E).
(i) Where the communication conductors consist of individual paired conductors only, supply conductors in the upper position need only be grade N due to this condition.

Exception: Fire-alarm conductors shall always meet grade D where the span length is from 0 to 150 feet, and grade C where the span length exceeds 150 feet.

TABLE 15

Grades of Construction for Communication Conductors Alone, or in Upper Position at Crossings, at Conflicts, or on Joint Poles

Conductors, tracks and rights of way at lower levels		Communications conductors at higher levels (a)	Communication conductors rural or urban, open or cable, including communication conductors run as such, but used exclusively in the operation of supply lines. Major	Minor
Lines on fenced rights of way			N	N
Lines not on fenced rights of way			N	N
Railroad tracks		Main	D	D
		Minor	E	E
Street-railway tracks having no overhead contact wire			N	N
Constant-potential supply conductors. (b)	0 to 750 volts(c)	Open or cable	N	N
	750 to 5000 v.(d)	Open or cable	C	C
	5000 to 7500 v.(e)	Open	B	(g)C
		Cable	C	C
	Exceeding 7500 volts (f)	Open	A	B
		Cable	C	C
Constant current supply conductors (b)	0 to 7.5 amp.	Open (i)	C	C
	7.5 to 10 amp.	Open (i)	B	(g)C
	Exceeding 10 amp.	Open (i)	A	B
Direct-current railway feeders (b)	0 to 750 volts	Open or cable	N	N
	Exceeding 750 v.	Open or cable	A	B
Trolley Contact Conductors	0 to 750 volts	A. C. or D. C.	(h)D	(h)D
	Exceeding 750 v.	A. C.	A. B, or C.	See order 1242, B
		D. C.	A	B
Communication conductors, open or cable used exclusively in the operation of Supply Lines.			B, C, or N See Order 1242 C	
Communication conductors, open or cable, urban or rural, major or minor.			N	N

(a) It is recommended that the placing of communication conductors above supply conductors at crossings, conflicts, or jointly used poles be avoided, unless the supply conductors are trolley contact conductors and their associated feeders.

(b) The words "open" and "cable" appearing in the headings have the following meaning as applied to supply conductors. "Cable" means the specially installed cables described in Order 1241, A, 1. "Open" means open wire and also supply cables not "specially installed".

(c) Voltages to neutral or ground of 0 to 440 volts.

(d) Voltages to neutral or ground of 440 to 2,900 volts.

(e) Voltages to neutral or ground of 2,900 to 4,400 volts.

(f) Voltages to neutral or ground exceeding 4,400 volts.

(g) For spans 150 feet or less in length grade C supply-conductor sizes and sags shall apply instead of grade D as permitted by Order 1261H.

(h) Applies only to line-conductor sizes and sags in spans 0 to 150 feet long with the following exceptions. Copper or steel, spans 0—100 feet, use No. 12 wire; steel, spans 125—150 feet, use No. 9 wire. For spans exceeding 150 feet, grade C supply-conductor sizes and sags shall be met. For paired conductors, grade C paired-conductor requirements shall be met.

(i) Where constant-current circuits are in specially installed cable, they are considered on the basis of the nominal full-load voltage.

Order 1243. Grades of Supporting Structures.

A. *Poles or Towers.* The grade of construction shall be that required for the highest grade of conductors supported.

Note: See 180.18 of 1933 statutes for additional R. R. crossing requirements.

Exception 1: The grade of construction of joint poles, or poles used only by communication lines, need not be increased merely because of the fact that communication wires carried on such poles cross over trolley contact conductors of 0 to 750 volts.

Exception 2: Poles carrying grade C or D fire-alarm conductors, where alone, or where concerned only with other communication conductors, need meet only the requirements of grade N.

Exception 3: Poles carrying supply service loops of 0 to 750 volts shall have at least the grade of construction required for supply line conductors of the same voltage.

Exception 4: Where communication lines cross over supply conductors and a railroad in the same span and grade A or B is required by Order 1241, D, 3, (c) for the communication conductors, due to the presence of railroad tracks, the grade of the poles or towers shall be D or E.

Exception 5: At structure conflicts even though no conductor conflict exists, the grade of construction which would be required by Order 1242, if the conductors were in conflict, shall be applied to the pole or tower.

Note: This requirement may result in a higher grade of construction for the pole or tower than for the conductors carried thereon.

Exception 6: In the case where a structure conflict does not exist, but any conductor is in conductor conflict, the grade of construction of the pole or tower is not required to meet the conductor grade due to the conductor conflict.

B. *Cross Arms.* The grade of construction shall be that required for the highest grade of conductors carried by the cross arm concerned.

Exception 1: The grade of construction of cross arms carrying only communication conductors need not be increased merely because of the fact that such conductors cross over trolley contact conductors of 0 to 750 volts.

Exception 2: Cross arms carrying grade C or D fire-alarm conductors, where alone or where concerned with other communication conductors need meet only the requirements for grade N.

Exception 3: Cross arms carrying supply service loops of 0 to 750 volts shall have at least the grade of construction required for supply line conductors of the same voltage.

Exception 4: Where communication lines cross over supply conductors and a railroad in the same span and grade A or B is required by Order 1241, D, 3, (c) for the communication conductors due to the presence of railroad tracks, the grade of the cross arm shall be D or E.

C. *Pins, Insulators, and Conductor Fastenings.* The grade of construction shall be that required for the conductor concerned.

Exception 1: The grade of construction of pins, insulators, and conductor fastenings carrying only communication conductors need not be increased merely because of the fact that such conductors cross over trolley contact conductors of 0 to 750 volts.

Exception 2: In case of grade C or D fire-alarm conductors where alone or where concerned only with other communication conductors, pins, insulators, and conductor fastenings need meet only the requirements for grade N.

Exception 3: In the case of supply service loops of 0 to 750 volts, pins, insulators, and conductor fastenings shall have at least the same grade of construction as required for supply line conductors of the same voltage.

Exception 4: Where communication lines cross over supply conductors and a railroad in the same span, and grade A or B is required by Order 1241, D, 3, (c) for the communication conductors due to the presence of railroad tracks, the grade of pins, insulators, and conductor fastenings shall be D or E.

Exception 5: In case communication conductors are required to meet grade A, B, or C, the insulators need meet only the requirements for mechanical strength for these grades.

SECTION 125. LOADING FOR GRADES A, B, C, D, AND E

Order 1250. Loading Map.

Three degrees of severity are recognized in the U. S. for the loading, due to weather conditions, and are designated, respectively as heavy, medium, and light loading. The districts in which these loadings apply are determined by weather reports as to wind and ice and by local experience of utilities using overhead lines. The state of Wisconsin is considered as being in the heavy loading district. No data will therefore be given on light and medium loading. (See Order 1251)

Order 1251. Assumed Weather Conditions.

The following weather conditions are assumed to act simultaneously in different loading districts:

	Thickness of ice	Horizontal wind pressure on projected area of cylindrical surface	Temperature
	Inches	Lbs. per sq. ft.	° F.
Heavy Loading Districts (H)	0.50	8	0
Medium Loading Districts (M)	.25	8	+15
Light Loading Districts (L)	None	12	+30

Order 1252. Light and Medium Loading.

If anyone desires to obtain a further description of light and medium loading they should refer to "The National Electrical Safety Code" published by the Bureau of Standards.

Order 1253. Conductor Loading.

The loading on conductors shall be assumed as in A, below.

Where cables are concerned, the loadings shall be applied to both cable and messenger.

In applying loadings to bare stranded conductors, the coating of ice shall be considered as a hollow cylinder touching the outer strands.

Ice is assumed to weigh 57 pounds per cubic foot.

A. *Heavy Loading (H)* The resultant loading, due to the weight of the conductor plus the added weight of a layer of ice 0.5 inch in radial thickness, combined with a transverse horizontal wind pressure of 8 pounds per square foot on the projected area of the ice-covered conductor, shall be called heavy loading. The minimum temperature shall be assumed as 0° F.

Order 1254. Loads upon Line Supports.

A. *Assumed Vertical Loading.* The vertical loads upon poles, towers, foundations, cross arms, pins, insulators, and conductor fastenings shall be their own weight plus the superimposed weight which they support, including all ice covered wires and cables, together with the effect of any difference in elevation of supports. The radial thickness of ice shall be computed only upon wires, cables, and messengers, and shall be taken as 0.50 inch of ice. Ice is assumed to weigh 57 pounds per cubic foot.

Note: The weight of ice upon supports is ignored for the sake of simplicity. (See Appendix D, Table 72, for vertical loads of conductors)

B. *Assumed Transverse Loading.* In computing the stresses in poles, towers, and side guys the loading shall be taken as follows:

1. Heavy Loading. A Horizontal wind pressure, at right angles to the direction of the line, of 8 pounds per square foot upon the projected area of cylindrical surfaces of all supported conductors and messengers, when covered with a layer of ice 0.5 inch in radial thickness and on surfaces of the poles and towers without ice covering, shall be called heavy loading. (See 3 and 4 following.)

For supporting structures carrying more than 10 wires, not including cables supported by messengers, where the pin spacing does not exceed 15 inches, the transverse load shall be calculated on two-thirds of the total number of such wires with a minimum of 10 wires.

2. Trolley Contact Conductors. When a trolley contact conductor is supported on a commonly used pole it shall be included in the computation of the transverse load on the structure.

3. Flat Surfaces. For flat surfaces the assumed unit wind pressure shall be increased by 60 per cent. Where latticed structures are concerned the actual exposed area of one lateral face shall be increased by 50 per cent to allow for the pressure on the opposite face; this total, however, need not exceed the pressure which would occur on a solid structure of the same outside dimensions. The results obtained by more exact calculations may be substituted for the values obtained by this simple rule.

4. Angles. In cases where, due to change in direction of conductors, an unbalanced side pull is imposed on the supporting structure, a transverse load shall be assumed equal to the resultant of all conductor and messenger tensions, as determined by the loadings of Order 1253.

C. *Assumed Longitudinal Loading.* 1. Change in grade of construction. The longitudinal loading upon supporting structures, including poles, towers, cross arms, pins, and conductor fastenings, at ends of sections required to be of grade A or B construction when located in lines of a lower grade of construction, shall be taken as an unbalanced pull in the direction of the higher grade section equal to the total pull in one direction of all conductors and cables supported thereon, the conductor loading to be that given in Order 1253.

Exception: For such higher-grade sections having no span exceeding 500 feet in length where the total pull in the direction of the higher-grade section exceeds 30,000 pounds, the assumed loading is modified to 30,000 pounds, plus one-fourth the excess above 30,000 pounds, with a maximum of 50,000 pounds.

2. Same Grade of Construction Throughout. Where lines are built throughout their length, or between dead-ended points, of grade A or B construction respectively, although not so required, the longitudinal loading upon supporting structures (including poles, towers, cross arms, pins, and conductor fastenings) at crossings, at ends of sections of joint use, and at ends of conflicts required to be of

grade A or B construction, respectively, shall be taken as an unbalanced pull in the direction of the crossing, conflict, or joint-use section equal to the pull of one-third of the total number of conductors carried (not including overhead ground wires), such one-third of the conductors being selected so as to produce the maximum stress in the supports. If the application of the above results in a fractional part of a conductor, the nearest whole number shall be used.

3. Jointly Used Poles at Crossings over Railroads or Communication Lines. Where a joint line crosses over a railroad or a communication line and grade A or B is required for the crossing span, the tension in the communication conductors of the joint line may be considered as limited to one-half their breaking strength, provided they are smaller than No. 8 Stl. W. G., if of steel, or No. 6 A. W. G., if of copper, regardless of how small the initial sags of the communication conductors at 60° F.

4. Dead Ends. The longitudinal loading upon supporting structures shall be taken as an unbalanced pull equal to the tensions of all conductors and messengers under the conditions of loading specified in Order 1253.

5. Communication conductors on Unguyed Supports at Railroad Crossings. The longitudinal load shall be assumed equal to an unbalanced pull in the direction of the crossing of all conductors supported, the pull of each conductor being taken as one-half its ultimate strength.

D. *Average Span Lengths.* 1. General. The calculated transverse loads, upon poles, towers, and cross arms, except as provided in 2 below, shall be based upon the average span length of a section of line that is reasonably uniform as to height, number of wires, grade, and span length. In no case shall the average value taken be less than 75 per cent or more than 125 per cent of the actual average of the two spans adjacent to the structure concerned.

2. Crossings. In the case of crossings over railroads or communication lines (other than minor communication lines) the actual lengths of the two spans adjacent to the two structures concerned shall be used.

E. *Simultaneous Application of Loads.* 1. When calculating transverse strength, the assumed transverse and vertical loads shall be taken as acting simultaneously.

2. In calculating longitudinal strength, the assumed longitudinal loads shall be taken without consideration of the vertical or transverse loads.

SECTION 126. STRENGTH REQUIREMENTS

Order 1260. Preliminary Assumptions.

In calculation of stresses no allowance shall be made for deformation, deflection, or displacement of any part of the supporting structure, including suspension insulators.

Order 1261. Grades A, B, and C Construction.

A. *Poles and Towers.* The strength requirements for poles and towers may be met by the structures alone or with the aid of guys or braces.

1. Average Strength of Three Poles. A pole (single-base structure) not individually meeting the transverse strength requirements will be permitted when reinforced by a stronger pole on each side, if the average strength of the three poles meets the transverse strength requirements, and the weak pole has not less than 75 per cent of the required strength.

An extra pole inserted in a normal span for the purpose of supporting a service loop may be ignored, if desired, in the calculation of the strength of the line.

Exception for crossing poles: In the case of crossings over railroads or communication lines (other than minor communication lines), the actual strengths of the crossing poles shall be used.

2. Reinforced-Concrete Poles. Reinforced-concrete poles shall be of such material and dimensions as to withstand for transverse strength the loads assumed in Order 1254, A and B and for longitudinal strength the loads in Order 1254, C without exceeding the following percentages of their ultimate strength. (Where guys are used, see Order 1261, C).

	Percentages of ultimate strength for different grades		
	Grade A	Grade B	Grade C
For transverse strength (when installed)	33⅓	50	75
For longitudinal strength (at all times) in general	100	100	----------
At dead ends	33⅓	50	75

3. Steel Supporting Structures. Steel supports, steel towers, and metal poles shall be designed and constructed so as to meet the following requirements:

(a) Transverse Strength. Under the transverse and vertical loads assumed in Order 1254, A and B the calcu-

lated stresses in steel members shall not exceed the allowable stresses for transverse strength given in (d) below.

(b) Longitudinal Strength. Grades A and B. Under the longitudinal loads assumed in Order 1254, C the calculated steel members shall not exceed the allowable stresses for longitudinal strength given in (d) below.

Grade C. No longitudinal-strength requirements except at dead ends.

(c) Minimum Strength. Steel towers shall have strength sufficient to withstand a transverse load on the towers without conductors due to three times the specified transverse wind pressure, without exceeding the allowable stresses for longitudinal strength in Table 16.

(d) Allowable Unit Stresses; Steel. The values in Table 16 for structural steel are for material having an ultimate tensile stress between 55,000 and 65,000 pounds per square inch and yield point not less than 50 per cent of the ultimate stress.

In the case of special steels having higher yield points, purchased under rigid specification and inspection conditions, an allowance above the tabular stresses in proportion to the respective yield points will be permitted.

As the unit stresses in Table 16 are the maximum allowable, sufficient allowance should be made in the design to insure that in the completed structure the specified unit stresses will not be exceeded.

TABLE 16

Allowable Unit Stresses in Steel for Transverse and Longitudinal Strengths

	Allowable stresses for transverse strength			Allowable stresses for longitudinal strength	
	Grade A	Grade B	Grade C	Grades A and B Crossings	Grades A and B except at Crossings
	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.
Structural steel:					
Tension	20,000	26,000	30,000	30,000	33,000
Compression	20,000 −80L/R	26,000 −90L/R	30,000 −100L/R	30,000 −100L/R	33,000 −100L/R
Bolts:					
Shear	20,000	24,000	35,000	35,000	40,000
Bearing	40,000	48,000	70,000	70,000	80,000
Rivets:					
Shear	18,000	22,000	30,000	30,000	33,000
Bearing	36,000	44,000	60,000	60,000	66,000

(e) Thickness of Steel. Steel poles or towers shall have no less thickness of metal in members than the following:

TABLE 17

Thickness of Steel

Kind of Member	Thickness of main members of cross arms and legs	Thickness of other Members
	Inches	Inches
Galvanized:		
For localities where experience has shown deterioration of galvanized material is rapid	¼	5/16
For other localities	3/16	⅛
Painted	¼	a¼

a. Painted bracing members having L/R not exceeding 125 may be 5/16 inches in thickness.

(f) Unsupported Length of Compression Members. The ratio of L, the unsupported length of a compression member, to R, the least radius of gyration of the member, shall not exceed the following: (These figures do not apply to the complete structure.)

TABLE 18

L/R for Compression Members

Kind of compression member	L/R
Leg members	150
Other members having figured stresses	200
Secondary members without figured stresses	250

(g) Splices for Main Leg Members. In splices for main leg members where under the application of the values in Table 16, Order 1261, A, 3, (d) four or more bolts or rivets are called for, the number of bolts or rivets shall be increased by 10 per cent with a minimum of one additional bolt or rivet.

(h) Additional Requirement for Anchor Towers. When steel supports or towers are used which are not capable of withstanding approximately as great a force longitudinally as transversely, anchor towers shall be placed at intervals not greater than 10 spans. These anchor towers shall be able to withstand the combined longitudinal tension of all conductors under the loads specified in Order 1253 up to 10,000 pounds plus one-half the excess above 10,000 pounds, without exceeding their ultimate strength.

(i) General Construction Features. Steel poles or towers, including parts of footings above ground, shall be constructed so that all parts are accessible for inspection, clean-

ing, and painting, and so that pockets are not formed in which water can collect.

Recommendation: Unless sample structures, or similar ones, have been tested to assure the compliance of structures in any line with these requirements, it is recommended that structures be designed to have a computed strength at least 10 per cent greater than that required by these rules.

(j) Protective Covering or Treatment. All iron or steel poles, towers, or supporting structures shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

4. Wood Poles. Wood poles shall be of such material and dimensions as to meet the following requirements. Where guys are used, see Order 1261, C.

(a) Transverse Strength. Wood poles shall withstand the transverse and vertical loads assumed in Order 1254, A and B without exceeding at the ground line for unguyed poles, or at the point of guy attachment for guyed poles, the appropriate allowable fiber stresses given in Table 20.

(b) Longitudinal Strength. Grades A and B. The longitudinal strength of wood poles shall be maintained at all times so that they will withstand the longitudinal loading specified in Order 1254, C without exceeding at the ground line for unguyed poles, or at the point of guy attachment for guyed poles, the appropriate ultimate fiber stress given in Table 19.

Grade C. No longitudinal-strength requirements except at dead-ends.

(c) Ultimate Fiber Stress. Different kinds of wood poles are considered as having the ultimate fiber stresses given in Table 19. These ultimate fiber stresses are given so as to identify different kinds of pole timbers with the ultimate fiber stress appearing at the heads of the columns in Table 20.

TABLE 19

Ultimate Fiber Stresses of Wood Poles

Kind of Wood	Ultimate Fiber Stress
	lbs. per sq. in.
Southern yellow pine (creosoted)	7,400
Chestnut	6,000
Western cedar (Western red cedar)	5,600
Other yellow pine	5,000
Cypress	5,000
Eastern cedar (Northern white cedar)	3,600
Redwood	3,600

(d) Treated Poles. The use of treated poles is not required. However, under certain circumstances Table 20 permits higher allowable stresses for treated poles than for untreated poles. Treated poles are poles meeting the following requirements:

(1) Preservatives. The preservative used shall be coal-tar creosote or other preservative equally satisfactory with regard to electrical resistance, retention of the preservative within the timber, and efficiency as a preservative. In the case of poles which are butt-treated only, the electrical resistance of the preservative may be disregarded.

(2) Full-length Treatment. Pine and other timber subject to rapid decay above ground shall be treated full length by a pressure process or some other equally effective method.

(3) Butt Treatment. Cedar, chestnut, and other timber not subject to rapid decay above ground shall be treated by any process which will produce impregnation of most of the sapwood from at least 2 feet below the ground line to at least 1 foot above the ground line. In the case of treatments which require perforation, no method shall be used which results in perforation to the cross section required at replacement.

(e) Allowable Fiber Stresses. The allowable fiber stresses to be used in computing the strength of treated and untreated poles to withstand vertical and transverse loads are given in Table 20.

TABLE 20

Allowable Fiber Stresses (in Pounds per Square Inch) for Wood Poles Under Vertical and Transverse Loading

	When installed									At replacement				
	Treated poles					Untreated poles				Treated or untreated poles				
	For ultimate fiber stress of—					For ultimate fiber stress of—				For ultimate fiber stress of—				
	7,400	6,000	5,600	5,000	3,600	6,000	5,600	5,000	3,600	7,400	6,000	5,600	5,000	3,600
At crossings:														
Poles in lines of one grade of construction throughout														
Grade A	2,470	2,000	1,870	1,670	1,200	2,000	1,870	1,670	1,200	3,700	3,000	2,800	2,500	1,800
Grade B	3,700	3,000	2,800	2,500	1,800	3,000	2,800	2,500	1,800	5,550	4,500	4,200	3,750	2,700
Grade C	5,550	4,500	4,200	3,750	2,700	4,500	4,200	3,750	2,700	11,100	9,000	8,400	7,500	5,400
Poles in isolated sections of higher grade of construction in lines of a lower grade of construction—														
Grade A	2,470	2,000	1,870	1,670	1,200	1,500	1,400	1,250	900	3,700	3,000	2,800	2,500	1,800
Grade B	3,700	3,000	2,800	2,500	1,800	2,000	1,870	1,670	1,200	5,550	4,500	4,200	3,750	2,700
Grade C	5,550	4,500	4,200	3,750	2,700	3,600	3,360	3,000	2,160	11,100	9,000	8,400	7,500	5,400
Elsewhere than at crossings:—														
Grade A	2,960	2,400	2,240	2,000	1,440	2,000	1,870	1,670	1,200	4,440	3,600	3,360	3,000	2,160
Grade B	4,440	3,600	3,360	3,000	2,160	3,000	2,800	2,500	1,800	7,400	6,000	5,600	5,000	3,600
Grade C	7,400	6,000	5,600	5,000	3,600	4,500	4,200	3,750	2,700	11,100	9,000	8,400	7,500	5,400

(f) Freedom from Defects. Wood poles shall be selected timber free from observable defects that would decrease their strength and durability.

(g) Minimum pole Sizes. Wood poles shall have nominal top diameters not less than the following:

TABLE 21

MINIMUM TOP DIAMETERS FOR WOOD POLES

Grade of construction	Minimum top diameters Heavy loading
A	7 inches
B	6 inches
C	6 inches

(h) Spliced Poles. Spliced poles shall not be used at crossings, conflicts, or joint-use sections requiring grade A, B, or C construction.

5. Transverse Strength Requirements for Structures where side Guying is Required, but can only be Installed at a Distance.

Grades A and B. In the case of structures where, because of very heavy or numerous conductors or relatively long spans, the transverse-strength requirements of this section can not be met except by the use of side guys or special structures, and it is physically impracticable to employ side guys, the transverse-strength requirements may be met by side-guying the line at each side of and as near as practicable to, the crossing or other transversely weak structure, and with a distance between such side-guyed structures of not over 800 feet provided that:

(a) The side-guyed structures for each such section of 800 feet or less shall be constructed to withstand the calculated transverse load due to wind on the supports and ice-covered conductors, on the entire section between the side-guyed structures.

(b) The line between such side-guyed structures shall be substantially in a straight line and the average length of span between the side-guyed structures shall not be in excess of 150 feet.

(c) The entire section between the transversely strong structures shall comply with the highest grade of construction concerned in the given section, except as to the transverse strength of the intermediate poles or towers.

Grade C. The above provision is not applicable to Grade C.

6. Longitudinal-Strength Requirements for Sections of Higher Grade in Lines of a Lower Grade of Construction.

(a) Methods of Providing Longitudinal Strength. Grades A and B. The longitudinal-strength requirements for sections of line of higher grade in lines of a lower grade (see for assumed longitudinal loading Order 1254, C, 1) are usually met by placing supporting structures of the required longitudinal strength at either end of the higher-grade section of the line.

Where this is impracticable, the supporting structures of the required longitudinal strength may be located one or more span lengths away from the section of higher grade, within 500 feet on either side and with not more than 800 feet between the longitudinally strong structures, provided such structures, and the line between them meet the requirements, as to transverse strength and stringing of conductors, of the highest grade occurring in the section, and pro-

vided that the line between the longitudinally strong structures is approximately straight or suitably guyed.

The requirements may also be met by distributing the head guys over two or more structures on either side of the crossing, such structures and the line between them complying with the requirements for the crossing as to transverse strength and as to conductors and their fastenings.

Where it is impracticable to provide the longitudinal strength, the longitudinal loads shall be reduced by increasing the conductor sags. This may require greater conductor separations. (See Order 1235, A, 2, (a)).

Grade C. The above provision is not applicable to Grade C.

(b) Flexible Supports. Grades A and B. When supports of the section of higher grade are capable of considerable deflection in the direction of the line, as with wood or concrete poles, or some types of metal poles and towers, it may be necessary to increase the normal clearances specified in section 123, or to provide head guys or special reinforcement to prevent such deflection.

So-called flexible steel towers or frames, if used at such locations, shall be adequately reinforced to meet the requirements of Order 1261, A, 3 (b).

When the situation is one involving an isolated crossing of higher grade in a line of lower-grade construction, then the structure shall, when practicable, be head-guyed or otherwise reinforced to prevent reduction in the clearances required in section 123.

Grade C. The above provision is not applicable to grade C.

7. Strength at Angles and Dead Ends. In cases where, due to change of direction of the line or because of dead ends, the longitudinal tensions in the conductors are not normally balanced, the construction shall be such as to withstand the total combined load without exceeding the working stresses for transverse strength.

Where the section of higher grade is not in line with the line beyond this section, suitable guys shall be placed to withstand the resulting transverse forces.

B. *Foundations.* 1. Use of Foundations. (a) Wood and Reinforced-Concrete poles. No special foundation construction is generally required.

(b) Steel Poles or Towers. Steel poles or towers should preferably be placed on concrete or other suitable foundations extending above the ground line. If, however, the

steel is set in earth, it shall be suitably protected against injurious corrosion at and below the ground line.

2. Strength of Foundations. (a) Steel Supports. The foundations shall be so designed and constructed as to withstand the stresses due to the loads assumed in Order 1254. The calculated stresses in any steel parts shall not exceed the stresses specified in Order 1261, A, 3, (d).

Since in many localities the soil and climatic conditions are such as to alter the strength of foundations considerably from time to time, there should usually be provided a considerable margin of strength in foundations above that which (by calculation) will just withstand the loads under the assumption of average conditions of climate and soil.

(b) Wood and Concrete Poles. Foundations for poles shall be of such material and dimensions as to withstand the loads assumed in Order 1254, A, B, and C without exceeding the following percentages of their ultimate strength.

	Percentages of ultimate strength for different grades		
	Grade A	Grade B	Grade C
For transverse loads (when installed)	50	50	75
For longitudinal loads (at all times) in general	100	100	----------
At dead ends	50	50	75

C. *Guys.* 1. General. The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (see sec. 128).

2. For lines in exposed locations. Grades A and B. In exposed situations, such as open country in rural districts, the transverse strength of wood or reinforced concrete crossing poles in sections of higher grade in lines of a lower grade of construction shall, where practicable, be obtained by the use of side guys in the following situations:

Where more than ten wires are carried, for all span lengths.

Where more than six wires are carried if the span length exceeds 150 feet.

Grade C. The above provisions do not apply to grade C.

3. On Steel Structures. The use of guys to obtain compliance with these requirements is regarded as generally undesirable. When guys are necessarily used, the steel supports or towers, unless capable of considerable deflection, shall be regarded as taking all of the load up to their allowable working load, and the guys shall have sufficient

strength to take the remainder of the assumed maximum load. (See Order 1261, A, 6, (b) for flexible supports).

4. On Wood or Concrete Poles. When guys are used to meet the strength requirements for wood or concrete poles, they shall be considered as taking the entire load in the direction in which they act, the poles acting as struts only.

5. Strength of Guys. Guys, when used, shall be of such material and dimensions as will withstand the transverse load assumed in Order 1254, B and the longitudinal load assumed in Order 1254, C without exceeding the following percentages of their ultimate strength:

	Percentages of ultimate strength for different grades		
	Grade A	Grade B	Grade C
For transverse strength (when installed)	50	50	75
For longitudinal strength (at all times) in general	100	100	----------
At dead ends	50	50	75

D. *Cross Arms.* 1. Vertical Strength. Cross arms shall, when installed, withstand the vertical loads specified in Order 1254, A without the stress under these loads exceeding 50 per cent of the assumed ultimate stress of the material.

Exception: For built-up steel cross arms on steel structures, see Order 1261, A, 3, (d) for allowable working stresses in steel.

2. Bracing. Cross arms shall be securely supported by bracing, if necessary, so as to support safely all other loads to which they may be subjected in use, including linemen working on them. Any cross arm or buck arm except the top one shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

3. Longitudinal Strength. (a) General. Cross arms shall withstand any unbalanced longitudinal loads to which they are exposed, with a limit of unbalanced tension where conductor pulls are normally balanced, of 700 pounds at the outer pin.

(b) At Ends of Higher-Grade Construction in Line of Lower Grade. Grades A and B. Wood cross arms shall be of sufficient strength to withstand at all times, without exceeding their ultimate strengths, an unbalanced pull in the direction of the higher-grade section equal to the tension in all supported conductors under assumed maximum loading as given in Order 1254, C, 1. Steel arms shall

withstand this load without exceeding the working stresses for longitudinal loads given in Order 1261, A, 3, (d).

Grade C. The above provisions do not apply to Grade C.

(c) At Ends of Transversely Weak Sections. Grades A and B. The cross arms connected to the structure at each end of the transversely weak section, such as described in Order 1261, A, 5, shall be such as to withstand at all times without exceeding their ultimate strengths, under the conditions of loading prescribed in Order 1254, C, 1, an unbalanced load equivalent to the combined pull in the direction of the transversely weak section of all the conductors supported.

Grade C. The above provision does not apply to grade C.

(d) Methods of Meeting Orders 1261, D, 3, (b) and (c). Grades A and B. Where conductor tensions are limited to a maximum of 2,000 pounds per conductor, double wood cross arms fitted with spacing bolts equipped with spacing nuts and washers, pipe spacers, or similar construction, or with spacing blocks or plates, will be considered as meeting the strength requirements in (b) and (c) preceding.

Grade C. The above provisions do not apply to grade C.

4. Dimensions of Cross Arms of Selected Yellow Pine or Fir. The cross-sectional dimensions of selected yellow pine or fir cross arms shall not be less than values of Table 22.

TABLE 22

Cross Arm Cross Sections

Number of Pins	Grades A and B	Grade C	
	Inches	Supply Inches	Communication Inches
2 or 4	3 by 4	2¾ by 3¾	----------
6 or 8	3¼ by 4¼	3 by 4	----------
6	----------	----------	2¾ by 3¾
10	----------	----------	3 by 4

Note: Sec. 180.18 of the statutes requires double cross arms at railroad crossings.

5. Double Cross Arms at Angles or Dead Ends. Grades A and B. Where conductors are supported on pin insulators, double cross arms shall be used at unbalanced corners and dead ends in order to permit conductor fastenings at two insulators and so prevent slipping.

Grade C. The above provision does not apply to grade C.

6. Location. In general, cross arms should be maintained at right angles to the axis of the pole and to the

direction of the attached conductors. At crossings, cross arms should be attached to that face of the structure away from the crossing, unless special bracing or double cross arms are used.

E. *Pins and Conductor Fastenings.* 1. Longitudinal Strength. (a) General. Pins and ties or other conductor fastenings shall have sufficient strength to withstand an unbalanced tension in the conductor, up to a limit of 700 pounds per pin or fastening.

(b) At Ends of Higher-Grade Construction in Line of Lower Grade. Grades A and B. Pins and ties or other conductor fastenings connected to the structure at each end of the higher-grade section shall be of sufficient strength to withstand at all times without exceeding their ultimate strength, an unbalanced pull in the direction of the higher-grade section due to the loading specified in Order 1254, C, 1.

Grade C. The above provisions do not apply to grade C.

(c) At Ends of Transversely Weak Sections. Grades A and B. Pins and ties or other conductor fastenings connected to the structure at each end of the transversely weak section as described in Order 1261, A, 5 shall be such as to withstand at all times without exceeding their ultimate strength under conditions of loading prescribed in Order 1254, C, 1 the unbalanced pull in the direction of the transversely weak section of the conductor supported.

Grade C. The above provisions do not apply to grade C.

(d) Method of Meeting Orders 1261, E, 1, (b), and (c). Grades A and B. Where conductor tensions are limited to 2,000 pounds and such conductors are supported on pin insulators, double pins, and ties or equivalent fastenings will be considered to meet the requirements (b) and (c) preceding.

Grade C. The above provision does not apply to grade C.

2. Sharp Edges on Fastenings. Tie wires or fastenings shall have no sharp edges or burrs at contacts with the conductors.

3. Height of Pin. The height of the pin and the conductor fastenings and the material and cross section of the pin should be chosen so as to afford the required strength.

Note: The method of attaching conductors by suitable ties to single pin-type insulators mounted on 1½ by 9 inch wood pins of locust or equivalent wood will usually provide strength up to 1,000 pounds conductor tension with the conductor 3.5 inches above the cross arm. Steel pins may afford greater strength both for the pins and for the cross arms.

F. *Open Supply Conductors.* 1. (a) Material. Conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

Recommendation: It is recommended that medium-hard-drawn copper wire (conforming to the specifications of the American Society for Testing Materials) be used instead of soft in new construction, especially for sizes smaller than No. 2.

Note: Soft copper wire has a yield point less than one-half that of medium-drawn copper, and hence stretches permanently with a correspondingly lighter loading of ice and wind.

If the wire when first strung is pulled to a tension approximately equal to half its breaking strength and then released and tied, its yield point is thereby raised and it will be less likely to stretch and its sag to increase materially under moderate loading of ice and wind.

(b) All supply conductors in urban districts, except trolley contact conductors, operating at less than 5000 volts between conductors, when installed, shall have standard weatherproof covering or its equivalent.

2. Minimum Sizes of Supply Conductors. Supply conductors shall be not smaller than indicated in Table 23.

Exception 1: Longer spans than specified in the table may be used with any listed conductor size if the separations and clearances of Section 123 and the sags of Appendix A are correspondingly increased.

Exception 2: Supply service leads of 0 to 750 volts may have the sizes set forth in Order 1263, E.

Exception 3: Where the short-span method of construction is employed in accordance with Order 1261, K, the conductor sizes and sags herein specified are not required.

TABLE 23

Minimum Allowable Conductor Sizes

Kind of Wire	Loading District	Grade of Construction	Wire sizes for span lengths up to and including the following limits (in ft.)								
			150	175	200	250	300	400	500	700	1000
Covered wires: Copper, medium or hard-drawn; copper covered steel.	Heavy	A and B	6	4	4	----	2	----	----	----	----
		C	8	6	4	----	2	----	----	----	----
	Medium	A	6	4	4	----	2	----	----	----	----
		B	8	6	4	----	2	----	----	----	----
		C	8	6	4	----	2	----	----	----	----
	Light	A	6	6	4	----	2	----	----	----	----
		B	8	6	6	----	2	----	----	----	----
		C	8	8	6	----	2	----	----	----	----
Bare wires: Copper, medium or hard-drawn; copper covered steel.	Heavy	A and B	6	4	4	----	4	2	2	----	----
		C	8	6	4	----	4	2	2	----	----
	Medium	A	6	6	4	----	4	4	2	2	00
		B	8	6	4	----	4	4	2	2	00
		C	8	6	4	----	4	4	2	2	00
	Light	A	6	6	6	----	4	4	4	2	1
		B	8	6	6	----	4	4	4	2	1
		C	8	8	6	----	4	4	4	2	1
Covered or bare wires: Copper, soft-drawn	Heavy	A	4	2	1	----	----	----	----	----	----
		B	4	2	2	----	----	----	----	----	----
		C	6	2	2	----	----	----	----	----	----
	Medium	A and B	4	4	2	1	----	----	----	----	----
		C	6	4	2	1	----	----	----	----	----
	Light	A, B, and C	6	4	4	2	1	----	----	----	----
Steel wire	All	A and B	6	Exceeding 150							
		C	9	4							
				6							
Stranded aluminum wire: without steel reinforcem't	All	A, B and C	1	0							
with steel reinforcement	All	A, B and C	6	4							

3. Lightning Protection Wires. Lightning protection wires paralleling the line conductors shall be regarded in respect to size, material, separation, and stringing requirements as supply conductors with which they are associated.

4. Sags and Tensions. (a) Minimum Allowable Sag. Conductor sags shall be such that, under the assumed loading of Order 1253 the tension in the conductor shall not be more than 50 per cent of its breaking strength for grades A and B, nor more than 60 per cent for grade C.

The "National Electrical Safety Code" published by the Bureau of Standards contains a table of recommended sags which are greater than those in this code. These recommended sags are published as Appendix A to part two of the Bureau of Standards Code.

In order to minimize the danger from wires swinging together and to permit the moderate pin spacings and cross-arm spacings sanctioned by modern good practice in overhead line construction, it is necessary to assign a limit to the sag, and hence to the recommended length of span of the smaller sized wires, as indicated by the blank spaces in the tables.

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, is necessary
,000 pounds.
. Splices shall not
.eferably not in the ad-
.d upon for withstanding
.e crossing conductors. Taps
ossing span. If a splice or tap is
. in the span next to the crossover
, practicable, be placed at a point nearer
support than is the nearest conductor
crossed over.

Exception: In the case of large-gauge conductors where the application of this rule would work a hardship and where proper methods are available for making high-strength splices, such splices may be used in the crossing span provided they are of a type which has been shown by tests and experience to be at least as strong as the conductor.

Grade C. The above does not apply to grade C.

6. Trolley Contact Conductors. In order to provide for wear, no trolley contact conductor shall be installed of less size than No. 0, if of copper, of No. 4, if of silicon bronze.

G. *Supply Cables.* 1. Specially installed Supply Cables. Cables having permanently grounded continuous metal sheath or armor, where located on joint poles, or where located on other poles and having a grade of construction less than that required for open wire supply lines of the same voltage, shall meet the requirements of (a), (b), (c), and (d) below.

(a) Messengers. Messengers shall be stranded and of galvanized or copper-covered steel with strengths and sags as specified in Order 1262, J for grade D, or if of other sizes shall not be stressed beyond half their ultimate strength under the loadings specified in Order 1253.

(b) Grounding of Cable Sheath and Messenger. Each section of cable between splices shall be suitably and permanently bonded to the messenger wire at not less than two places. The messenger wire shall be grounded at the ends of the line and at intermediate points not exceeding 800 feet apart. (See section 103 for method)

(c) Cable Splices. Splices in the cable shall be made so that their insulation is not materially weaker than the remainder of the cable. The sheath or armor at the splice shall be made electrically continuous.

Kind of Wire	Load District		Less than 100 feet	100 to 130 feet	Exceeding 130 feet						
Covered wires: Copper, medium or hard-drawn; copper covered steel.	Heavy	A and B									
		C									
	Medium	A									
		B									
		C									
	Light	A	6								
		B	8								
		C	8	8							
Bare wires: Copper, medium or hard-drawn; copper covered steel.	Heavy	A and B	6	4	4	----				----	----
		C	8	6	4	----	4	2	2	----	----
	Medium	A	6	6	4	----	4	4	2	2	00
		B	8	6	4	----	4	4	2	2	00
		C	8	6	4	----	4	4	2	2	00
	Light	A	6	6	6	----	4	4	4	2	1
		B	8	6	6	----	4	4	4	2	1
		C	8	8	6	----	4	4	4	2	1
Covered or bare wires: Copper, soft-drawn	Heavy	A	4	2	1	----	----	----	----	----	----
		B	4	2	2	----	----	----	----	----	----
		C	6	2	2	----	----	----	----	----	----
	Medium	A and B	4	4	2	1	----	----	----	----	----
		C	6	4	2	1	----	----	----	----	----
	Light	A, B, and C	6	4	4	2	1	----	----	----	----
				Exceeding 150							
Steel wire	All	A and B	6	4							
		C	9	6							
Stranded aluminum wire: without steel reinforcem't	All	A, B and C	1	0							
with steel reinforcement	All	A, B and C	6	4							

3. Lightning Protection Wires. Lightning protection wires paralleling the line conductors shall be regarded in respect to size, material, separation, and stringing requirements as supply conductors with which they are associated.

4. Sags and Tensions. (a) Minimum Allowable Sag. Conductor sags shall be such that, under the assumed loading of Order 1253 the tension in the conductor shall not be more than 50 per cent of its breaking strength for grades A and B, nor more than 60 per cent for grade C.

The "National Electrical Safety Code" published by the Bureau of Standards contains a table of recommended sags which are greater than those in this code. These recommended sags are published as Appendix A to part two of the Bureau of Standards Code.

In order to minimize the danger from wires swinging together and to permit the moderate pin spacings and cross-arm spacings sanctioned by modern good practice in overhead line construction, it is necessary to assign a limit to the sag, and hence to the recommended length of span of the smaller sized wires, as indicated by the blank spaces in the tables.

(b) Two-Thousand-Pound Limitation for Conductor Tensions. In order to apply the methods given in Order 1261, D, 3, (d) and Order 1261, E, 1, (d) it is necessary that the conductor tension be limited to 2,000 pounds.

5. Splices and Taps. Grades A and B. Splices shall not be made in the crossing span and preferably not in the adjacent spans, which are depended upon for withstanding the longitudinal tension of the crossing conductors. Taps shall not be made in the crossing span. If a splice or tap is made in any conductor in the span next to the crossover span, it shall, where practicable, be placed at a point nearer to the crossover support than is the nearest conductor crossed over.

Exception: In the case of large-gauge conductors where the application of this rule would work a hardship and where proper methods are available for making high-strength splices, such splices may be used in the crossing span provided they are of a type which has been shown by tests and experience to be at least as strong as the conductor.

Grade C. The above does not apply to grade C.

6. Trolley Contact Conductors. In order to provide for wear, no trolley contact conductor shall be installed of less size than No. 0, if of copper, of No. 4, if of silicon bronze.

G. *Supply Cables.* 1. Specially installed Supply Cables. Cables having permanently grounded continuous metal sheath or armor, where located on joint poles, or where located on other poles and having a grade of construction less than that required for open wire supply lines of the same voltage, shall meet the requirements of (a), (b), (c), and (d) below.

(a) Messengers. Messengers shall be stranded and of galvanized or copper-covered steel with strengths and sags as specified in Order 1262, J for grade D, or if of other sizes shall not be stressed beyond half their ultimate strength under the loadings specified in Order 1253.

(b) Grounding of Cable Sheath and Messenger. Each section of cable between splices shall be suitably and permanently bonded to the messenger wire at not less than two places. The messenger wire shall be grounded at the ends of the line and at intermediate points not exceeding 800 feet apart. (See section 103 for method)

(c) Cable Splices. Splices in the cable shall be made so that their insulation is not materially weaker than the remainder of the cable. The sheath or armor at the splice shall be made electrically continuous.

(d) Cable Insulation. The conductors of the cable shall be insulated so as to withstand a factory potential test of at least twice the operating voltage at operating frequency applied continuously for five minutes between conductors and between any conductor and the sheath or armor.

2. Other Supply Cables. The following requirements apply to all supply cables not included in 1 above.

(a) Messenger. The messenger shall have such strength and sag that it will not be stressed beyond the following percentages of its ultimate strength under the loadings specified in Order 1253.

Grade of Construction	Percentage of Ultimate Strength
A and B	50
C	60

(b) Cable. There are no strength requirements for cables supported by messengers.

H. *Open Communication Conductors.* Open-wire communication conductors in grade A, B, or C construction shall have the sizes and sags given in Order 1261, F, 2, and 4 for supply conductors of the same grade.

Exception: Where the span length is 150 feet or less, conductors may have grade D sizes and sags instead of grade C sizes and sags except as provided in Note g to Table 15, Order 1242.

I. *Communication Cables.* 1. Metal-Sheathed Communication Cables. There are no strength requirements for such cables supported by messengers.

2. Messenger. The messenger shall have such strength and sag that it will not be stressed beyond the following percentages of its ultimate strength under the loading specified in Order 1253:

Grade of Construction	Percentage of Ultimate Strength
A and B	50
C	60

J. *Paired Communication Conductors.* 1. Paired Conductors Supported on Messenger. (a) Use of Messenger. A messenger may be used for supporting paired conductors in any location, but is only required for paired conductors crossing over trolley contact conductors of more than 7,500 volts.

(b) Sag of Messenger. Messenger used for supporting paired conductors required to meet grade A or B construction because of crossing over trolley contact conductors shall meet the sag requirements for grade D messengers.

(c) Size and Sag of Conductors. There are no requirements for paired conductors when supported on messenger.

2. Paired Conductors not supported on Messenger. (a) Above Supply Lines. Grades A and B. Sizes and sags shall not be less than those required by Order 1261, F, 2 and 4 for supply conductors of similar grade.

Grade C.

Spans 0 to 100 feet. No sag requirements. Sizes shall be not less than the following:

Hard-drawn copper	No. 14 AWG
Bronze	No. 17 AWG
Copper-covered steel	No. 17 AWG

Spans 100 to 150 feet. Sizes and sags shall be not less than required for grade D communication conductors.

Spans exceeding 150 feet. Sizes and sags shall be not less than required for Grade C supply conductors.

(b) Above Trolley Contact Conductors. Grades A and B. Sizes and sags shall not be less than the following:

Spans 0 to 100 feet. No size requirements. Sags shall be not less than for No. 8 A. W. G. hard-drawn copper as given in Appendix A.

Spans exceeding 100 feet. Sizes shall be not less than the following:

Hard-drawn copper	No. 14 AWG
Bronze	No. 17 AWG
Copper-covered steel	No. 17 AWG

Sags shall be not less than for No. 8 A. W. G. hard-drawn copper as given in Appendix A.

Grade C. Sizes and sags shall be as follows:

Spans 0 to 100 feet. No requirements.

Spans exceeding 100 feet. No sag requirements. Size shall be not less than the following:

Hard-drawn copper	No. 14 AWG
Bronze	No. 17 AWG
Copper-covered steel	No. 17 AWG

K. *Short-span Crossing Construction.* Where supply lines cross over railways or communication lines by the short-span method, the requirements for grade A, B, or C conductor sags and sizes are waived, in so far as such grades are required by the crossing, provided that a permanently grounded guard arm is installed at each cross-

over support in such a manner as to prevent conductors which break in either adjoining span from swinging back into the conductors crossed over, or in the case of a railroad crossing into the space between the crossing supports.

Explanation: The short-span method of crossing requires the cross-over span to be of such a height that a conductor breaking in that span can not come within 15 feet of the ground or rails at a railroad crossing or make contact with any wires crossed over at a wire crossing.

This character of construction is facilitated where the cross-over supports can be placed quite near together and in the case of wire crossings where the span crossed over is at a minimum elevation above ground.

L. *Cradles at Supply Line Crossings.* Cradles should not be used.

Note: It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

M. *Protective Covering or Treatment for Metal Work.* All hardware, including bolts, washers, guys, anchor rods and similar parts of material subject to injurious corrosion under the prevailing conditions, shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

Order 1262. Grades D and E Construction.

A. *Poles.* 1. Strength of unguyed poles. Unguyed poles, at the time of installation, shall withstand the vertical and transverse loads specified in Order 1254, A and B and the longitudinal loads specified in Order 1254 C without exceeding the following percentages of their ultimate strength.

	Percentages of ultimate strength for different grades	
	Grade D	Grade E
For transverse strength	25	37.5
For longitudinal strength (for poles carrying not more than two wires)	50	75

2. Strength of guyed poles. Where poles are guyed, the poles shall be considered as acting as struts, resisting the vertical component of the tension in the guy calculated as in Order 1262, C combined with the vertical load.

3. Strength Requirements for Poles Where Guying is Required, but Can Only be Installed at a Distance. Where on account of physical conditions it is impracticable to guy

Average Length of Span	Allowable Vertical Distance Feet

shall be
direction in
swing percentages
nal.

	Percent
	50
	75

or Longitudinal Strength. (a) Direction
ys. Poles supporting the crossing span shall be
guyed away from the crossing.

(a) Size and Number of Head Guys. Guys for various wire loads shall be supplied as per Table 25.

Exception: This rule does not prevent the omission of head guys where the crossing poles have the strength specified in Order 1262, A, 1 above and carry not more than two wires.

TABLE 25

Strength (in Pounds) of Head Guys Required for Heavy Loading Districts

(Combinations of standard-size guys may be used)

Number of Wires	Ratio of guy lead to height not less than				
	1¼	1	¾	⅔	½
Grade D. Heavy Loading					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	6,000
10	6,000	6,000	6,000	10,000	10,000
20	10,000	10,000	12,000	16,000	16,000
30	16,000	16,000	20,000	20,000	26,000
40	20,000	20,000	26,000	26,000	32,000
50	20,000	20,000	30,000	32,000	42,000
60	26,000	30,000	36,000	36,000	48,000
70	30,000	30,000	40,000	48,000	60,000
80	36,000	40,000	48,000	60,000	70,000
Grade E. Heavy Loading					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	4,000
10	4,000	4,000	6,000	6,000	6,000
20	6,000	10,000	10,000	10,000	12,000
30	10,000	10,000	12,000	16,000	16,000
40	12,000	16,000	16,000	16,000	20,000
50	16,000	16,000	20,000	20,000	26,000
60	20,000	20,000	26,000	26,000	30,000
70	20,000	20,000	26,000	30,000	36,000
80	26,000	26,000	30,000	32,000	40,000

Note to Table 25. This table is based on ultimate or breaking strength of guys equal to seven-sixths of the nominal strengths shown in the Table and a wire load of 50 per cent No. 8 B. W. G. iron and 50 per cent No. 9 A. W. G. copper with an average pull of 408.75 pounds per wire. No guy will be required for a cable, since the suspension strand serves as a head guy.

5. Location of Guy Anchors. Guy anchors shall, where possible, be located so that the horizontal distance from the

stressed beyond one-half its ultimate strength. No over supports for longitudinal strength are made if the conwhich break in are balanced. Where conductor tensions into the conductors at a small angle in the line at one or road crossing into the span any of the wires, either guys

Explanation: The short-span method capable of withstanding such cross-over span to be of such a height that that span can not come within 15 feet of crossing Poles. The railroad crossing or make contact with any wire shall be such that wire crossing.

This character of construction is facilitated where the arms of the cross-supports can be placed quite near together and in the case of pole crossings where the span crossed over is at a minimum elevation above ground.

L. *Cradles at Supply Line Crossings.* Cradles should not be used.

Note: It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

M. *Protective Covering or Treatment for Metal Work.* All hardware, including bolts, washers, guys, anchor rods and similar parts of material subject to injurious corrosion under the prevailing conditions, shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

Order 1262. Grades D and E Construction.

A. *Poles.* 1. Strength of unguyed poles. Unguyed poles, at the time of installation, shall withstand the vertical and transverse loads specified in Order 1254, A and B and the longitudinal loads specified in Order 1254 C without exceeding the following percentages of their ultimate strength.

	Percentages of ultimate strength for different grades	
	Grade D	Grade E
For transverse strength	25	37.5
For longitudinal strength (for poles carrying not more than two wires)	50	75

2. Strength of guyed poles. Where poles are guyed, the poles shall be considered as acting as struts, resisting the vertical component of the tension in the guy calculated as in Order 1262, C combined with the vertical load.

3. Strength Requirements for Poles Where Guying is Required, but Can Only be Installed at a Distance. Where on account of physical conditions it is impracticable to guy

3. Guys Used for Transverse Strength. Guys shall be considered as taking the entire load in the direction in which they act, without exceeding the following percentages of the ultimate strength of the material.

	Percent
Grade D	50
Grade E	75

4. Guys used for Longitudinal Strength. (a) Direction of Head Guys. Poles supporting the crossing span shall be head guyed away from the crossing.

(b) Size and Number of Head Guys. Guys for various wire loads shall be supplied as per Table 25.

Exception: This rule does not prevent the omission of head guys where the crossing poles have the strength specified in Order 1262, A, 1 above and carry not more than two wires.

TABLE 25

Strength (in Pounds) of Head Guys Required for Heavy Loading Districts

(Combinations of standard-size guys may be used)

Number of Wires	Ratio of guy lead to height not less than				
	1¼	1	¾	⅔	½
Grade D. Heavy Loading					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	6,000
10	6,000	6,000	6,000	10,000	10,000
20	10,000	10,000	12,000	16,000	16,000
30	16,000	16,000	20,000	20,000	26,000
40	20,000	20,000	26,000	26,000	32,000
50	20,000	20,000	30,000	32,000	42,000
60	26,000	30,000	36,000	36,000	48,000
70	30,000	30,000	40,000	48,000	60,000
80	36,000	40,000	48,000	60,000	70,000
Grade E. Heavy Loading					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	4,000
10	4,000	4,000	6,000	6,000	6,000
20	6,000	10,000	10,000	10,000	12,000
30	10,000	10,000	12,000	16,000	16,000
40	12,000	16,000	16,000	16,000	20,000
50	16,000	16,000	20,000	20,000	26,000
60	20,000	20,000	26,000	26,000	30,000
70	20,000	20,000	26,000	30,000	36,000
80	26,000	26,000	30,000	32,000	40,000

Note to Table 25. This table is based on ultimate or breaking strength of guys equal to seven-sixths of the nominal strengths shown in the Table and a wire load of 50 per cent No. 8 B. W. G. iron and 50 per cent No. 9 A. W. G. copper with an average pull of 408.75 pounds per wire. No guy will be required for a cable, since the suspension strand serves as a head guy.

5. Location of Guy Anchors. Guy anchors shall, where possible, be located so that the horizontal distance from the

ground line of the pole to the guy or guy rod will be not less than the height above ground of the attachment of the guy to the poles for head guys, and not less than one-third that height for side guys.

6. Attachment of Guys to Poles. The guys shall be attached as near to the center of the load as practicable.

7. Maintenance. The guys and anchors shall be maintained so that the guys are kept taut.

D. *Cross Arms.* 1. Material. Wood cross arms supporting the crossing span shall be of yellow pine, fir, or other suitable timber.

2. Minimum Size. (a) Wood Cross Arms. Wood Cross arms shall have a cross section not less than the following:

Length of arm	Cross section (inches)
6 feet or less	2¾ by 3¾
More than 6 feet	3 by 4

(b) Steel or Iron Cross Arms. Galvanized or painted iron or steel cross arms of strength equal to wood cross arms may be used.

3. Double Cross Arms. Cross arms and insulators shall be double on the crossing poles. The cross arms shall be held together with properly fitted spacing blocks or bolts placed immediately adjoining the outside pins. Double cross arms shall not support more than 10 conductors.

E. *Brackets and Racks.* Brackets or racks may be used only if used in duplicate or otherwise designed so as to afford two points of support for each conductor.

Exception: For supporting paired conductors, a single metal bracket, designed to safely withstand the full dead-end pull of the wires, may be used.

F. *Pins.* 1. Material. Insulator pins shall be of steel, wrought iron, malleable cast iron, or locust or equivalent wood.

2. Strength. Insulator pins shall have sufficient strength to withstand the loads to which they may be subjected.

3. Size. (a) Wood Pins. Wood pins shall be sound and straight-grained with a diameter of shank not less than 1¼ inches.

(b) Metal Pins. Steel or iron pins shall have diameter of shank not less than one-half inch.

G. *Insulators.* Each insulator shall be of such pattern, design and material that when mounted it will withstand

without injury and without being pulled off the pin, the ultimate strength of the conductor attached to the insulator.

H. *Attachment of Conductor to Insulator.* The conductors shall be securely tied to each supporting insulator.

I. *Conductors.* 1. Material. Conductors shall be of hard-drawn copper, copper-covered steel, galvanized steel, or other hard-drawn corrosion-resisting metal, provided, however, that galvanized steel shall not be used in localities where excessive corrosion would result.

2. Size. Conductors of the crossing span, if of hard-drawn copper or galvanized steel, shall have sizes not less than specified in (a) and (b) below. Conductors of material other than the above shall be of such size and so erected as to have a mechanical strength not less than that of the sizes of copper conductors given in (a) and (b) below.

(a) Spans not Exceeding 150 Feet. The sizes in Table 26 apply.

TABLE 26

Grades D and E Minimum Wire Sizes

(A. W. G. for copper; Stl. W. G. for steel)

Conductor	Loading District	Spans of 125 feet or less		Spans of 125 feet to 150 feet	
		Grade D	Grade E	Grade D	Grade E
Copper, hard-drawn	Heavy	10	10	9	10
Steel, Galvanized: In General	All	10	12	8	10

(b) Spans Exceeding 150 feet. If spans in excess of 150 feet are necessary, the size of conductors specified above or the sags of the conductors shall be correspondingly increased.

3. Paired Conductors Without Messengers. Paired wires without a supporting messenger shall be eliminated as far as practicable and where used shall meet the following requirements:

(a) Material. Each conductor shall be made of bronze, hard-drawn copper, or copper covered steel, and shall be tinned.

(b) Size. Each wire shall be not smaller than the following:

Hard-drawn copper	No. 14 A. W. G.
Bronze	No. 17 A. W. G.
Copper-covered steel	No. 17 A. W. G.

(c) Limiting Span Lengths. Paired wires shall in no case be used without a supporting messenger in longer spans than the following:

	Feet
For grade D construction	100
For grade E construction	125

4. Sags. Conductors of the crossing span shall be strung with sags not less than shown in Table 27.

TABLE 27

Minimum Stringing Sags of Bare Hard-Drawn Copper Wire or Steel Wire for Loading Districts Indicated

Heavy Loading

Length of span (in feet)	Sag (in inches)					
	100°F.	80° F.	60° F.	40° F.	20° F.	0° F.
75	5½	5	4	3¼	2¾	2¼
80	6½	5½	4½	3½	3	2½
90	8	7	5½	4½	3½	3
100	10	8½	7	5½	4½	4
110	12	10	8½	6½	5½	5
120	14	12	10	8	6½	6
130	17	14	12	9½	8	7
140	20	17	14	11	9½	8
150	23	20	16	13	11	9

5. Splices and Taps. Splices and taps shall not be made in the crossing span and preferably not in the adjacent spans.

6. Simultaneous Crossing over Railroad and Supply Line. Where conductors cross in the same span over a railroad track and a supply line carrying from 750 volts alternating current (440 volts to neutral or ground) to 5,000 volts alternating current (2,900 volts to neutral or ground) the minimum allowable conductor sizes shall be the same as required by Order 1261, F, 2 for grades A and B construction when crossing main and minor tracks respectively.

J. *Messengers.* 1. Minimum Size. (a) Spans not Exceeding 150 Feet. Table 28 gives the minimum sizes of galvanized steel-strand messenger to be used for supporting different sizes of cables:

TABLE 28

Minimum Sizes of Messenger

Size of cable in weight per foot	Messenger (nominal breaking load) pounds
Less than 2.25 pounds	6,000*
2.25 to 5 pounds	10,000
Exceeding 5 and less than 8 pounds	16,000

* Where only light cables or a small number of twisted pairs are supported by a messenger, and riding the cable is prohibited, a 5000# messenger may be used.

(b) Spans Exceeding 150 Feet. For spans exceeding 150 feet or for heavier cables a proportionately larger messenger or other proportionately stronger means of support shall be used.

2. Sags and Tensions. Multiple-wire cables and their messengers shall be suspended with a normal sag at 60° F., so that when they are subjected to the loading prescribed in Order 1253 the tension in the messenger will not exceed the following values of safe working tension:

TABLE 29

Safe Working Tension in Messengers

Nominal breaking load of messenger (in pounds)	Safe working tension of messenger
	pounds
6,000	3,500
10,000	5,900
16,000	9,500

K. *Inspection.* All parts of the supporting structures of the crossing span shall be examined annually by the owner and all defective parts shall be promptly restored to a safe condition.

Order 1263. Grade N. Construction.

A. *Poles and Towers.* Poles used for lines for which neither grade A, B, C, D, or E is required shall be of such initial size and so guyed or braced, where necessary, as to withstand safely the loads to which they may be subjected including linemen working on them.

B. *Guys.* The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (sec. 128).

C. *Cross-Arm Strength.* Cross arms shall be securely supported, by bracing if necessary so as to support safely loads to which they may be subjected in use, including linemen working on them. Any cross arm, or buck arm, except the top one, shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

Note: Double cross arms are generally used at crossings, unbalanced corners, and dead-ends in order to permit conductor fastenings at two insulators, and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used, and cross-arm guys are sometimes used.

D. *Supply-line Conductors.* 1. Material. All supply conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

2. Size. Supply-line conductors shall be not smaller than the following:

TABLE 30

Grade N Minimum Gauge Sizes for Supply-Line Conductors

(A. W. G. for copper and aluminum; Stl. W. G. for steel)

	Urban	Rural
Soft Copper	6	8
Medium or hard drawn-copper	8	8
Steel	9	9
	Urban and Rural	
Stranded aluminum	Spans 150 ft. or less	Spans exceeding 150 ft.
Not reinforced	1	0
Steel-reinforced	6	4

Recommendation: It is recommended that except as modified in table 23, Order 1261, F, 2, these minimum sizes for copper and steel are not used in spans longer than 150 feet for heavy-loading district.

E. *Supply Services.* 1. Material. All supply service conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

2. Size of Open-wire Services. (a) Seven Hundred and Fifty Volts or Less. Supply-service leads of 750 volts or less shall not be smaller than required by (1) or (2) below.

(1) Spans not exceeding 150 feet.

TABLE 31

Minimum Sizes of Service Leads Carrying 750 Volts or Less

(A. W. G. for copper; Stl. W. G. for steel.)

Situation	Copper Wire		Steel wire
	Soft-drawn	Medium or hard-drawn	
Alone	10	12	12
Concerned with communication conductors	10	12	12
Over supply conductors of 0–750 volts	10	12	12
750 to 7,500 volts (a)	8	10	12
Exceeding 7,500 volts (a)	6	8	9
Over trolley contact conductors			
0 to 750 volts a. c. or d. c.	8	10	12
Exceeding 750 volts d. c.	6	8	9

(a) Installation of service leads of not more than 750 volts over supply lines of more than 750 volts should be avoided where practicable.

(2) Spans exceeding 150 Feet. Sizes shall not be smaller than required for Grade C. (Order 1261, F, (2), (b)), exceeding 750 volts. Sizes of supply-service leads of more than 750 volts shall be not less than required for supply-line conductors of the same voltage.

3. Sag, Open-Wire Services. (a) Seven Hundred and Fifty Volts or Less. Supply service leads of 750 volts or less shall have sags not less than the following.

TABLE 32

Sags for Open-Wire Services

Span lengths (in feet)	Sag
	Inches
100 or less	12
100 to 125	18
125 to 150	27
Exceeding 150	Grade C sags. (See tables of Appendix A)

(b) Exceeding 750 volts. Supply service leads of more than 750 volts shall comply as to sags with the requirements for supply line conductors of the same voltage.

4. Cabled Services. Supply service leads may be grouped together in a cable, provided the following requirements are met.

(a) Size. The size of each conductor shall be not less than required for leads of separate conductors (Order 1263, E, 2).

(b) Sag. The sag of the cable should be not less than required for leads of separate conductors (Order 1263, E, 3).

(c) Insulation. The insulation should be sufficient to withstand twice the normal operating voltage.

F. *Lightning Protection Wires.* Lightning protection wires paralleling the line conductors shall be regarded in respect to size and material requirements, as supply conductors.

G. *Trolley Contact Conductors.* In order to provide for wear, no trolley contact conductors shall be installed of less size than No. 0, if of copper, or No. 4, if of silicon bronze.

H. *Cradles at Supply-Line Crossings.* Cradles should not be used.

Note: It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

I. *Communication Conductors.* There are no specific requirements for grade N communication line conductors or service drops.

SECTION 127. LINE INSULATORS

Order 1270. Application of Rule.

These requirements apply only to situations where grade A or B construction is required. They do not apply to line insulators in grades C, D, E, or N construction.

Order 1271. Material and Marking.

Insulators for operation on supply lines at voltages of 2,300 and above shall be of porcelain, made by the wet process or one equally suitable as regards electrical and mechanical properties, or other material which will give equally good results in respect to mechanical and electrical performance and durability. These insulators should be marked by the maker with a classification number and maker's name or trade-mark, the marks being applied so as not to reduce the electrical or mechanical strength of the insulator.

Order 1272. Electrical Strength of Insulators in Strain Position.

Where insulators are used in strain position they shall have not less electrical strength than the insulators generally used on the line when under the normal mechanical stresses imposed by the loadings specified in section 125.

Order 1273. Ratio of Flash-Over to Puncture Voltage.

Insulators shall be designed so that their dry flashover voltage is not more than 75 per cent of their puncture voltage at a frequency of 60 cycles per second.

Order 1274. Test Voltages.

Insulators when tested under American Institute of Electrical Engineers' specifications shall flash-over at values not less than given in Table 33.

TABLE 33

Test Voltage Requirements

(Based on Line Conditions of Order 1276, B, 1.)

Nominal line voltage	Minimum test dry flash-over voltage of insulators
750	5,000
2,300	20,000
3,300	30,000
4,000	40,000
5,000	50,000
7,500	75,000
10,000	100,000
12,500	125,000
15,000	150,000
17,500	175,000
22,000	220,000
31,500	315,000
39,000	390,000
42,000	420,000
56,000	560,000

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B. *Suspension Ins*

Double cross arms on cross

Exception: This does not apply to

arms nor to steel cross arms used with a s

as per 2 (b) following.

2. Number of Insulator Strings. (a) Doub

Strings. Double strings of the insulators used on the

ing supports except under the special conditions covered

(b) following.

(b) Single Insulator Strings. Where preferred single strings of insulators may be used if all the following conditions obtain.

(1) Steel cross arms on steel poles or structures.

(2) Hardware throughout providing a factor of safety of not less than 2 against the assumed maximum tension in the conductor in one direction.

(3) A high-strength clamp which will prevent the conductor under assumed maximum loading conditions from slipping into the crossing span.

(4) An extra unit where strings of 5 or less are used elsewhere in the line and 2 extra units where strings of 6 or more are normally used, these extra units to be provided in addition to those in 4 below.

(1) Wood pins, ungrounded at the crossing supports, with wood or metal pins grounded or ungrounded throughout the line.

(b) Insulators which have a rating of 25 per cent greater than the requirements of Table 33, but not less than the insulators in the remainder of the line, under the following conditions:

(1) Wood pins, grounded at the crossing supports and throughout the line.

(2) Metal pins, grounded or ungrounded at crossing supports and throughout the line.

(c) Insulators at the crossing support which have a rating 50 per cent greater than those in the rest of the line, but not less than 25 per cent greater than required by Table 33 under the following conditions:

(1) Wood pins, grounded at crossing support and pins ungrounded throughout the remainder of the line.

(2) Metal pins, grounded at the crossing support and pins ungrounded throughout the remainder of the line.

(3) Metal pins, ungrounded at the crossing support with wood pins ungrounded throughout the remainder of the line.

B. *Suspension Insulators.* 1. Double Cross Arms. Double cross arms on crossing supports.

Exception: This does not apply to latticed or trussed steel cross arms nor to steel cross arms used with a single string of insulators as per 2 (b) following.

2. Number of Insulator Strings. (a) Double Insulator Strings. Double strings of the insulators used on the crossing supports except under the special conditions covered in (b) following.

(b) Single Insulator Strings. Where preferred single strings of insulators may be used if all the following conditions obtain.

(1) Steel cross arms on steel poles or structures.

(2) Hardware throughout providing a factor of safety of not less than 2 against the assumed maximum tension in the conductor in one direction.

(3) A high-strength clamp which will prevent the conductor under assumed maximum loading conditions from slipping into the crossing span.

(4) An extra unit where strings of 5 or less are used elsewhere in the line and 2 extra units where strings of 6 or more are normally used, these extra units to be provided in addition to those in 4 below.

3. Position of Insulator Strings. Insulators of the suspension type on crossing supports preferably should be used in the suspension or semistrain position except where conditions are such as to require the insulators to be used in the full-strain position.

4. Insulators in Suspended Position. (a) Ungrounded Crossing Supports. Insulators which meet the requirements of Table 33. In all cases the insulation at the crossing to be at least equal to that elsewhere in the line.

(b) Grounded Supports at the Crossing and Elsewhere in the Line. Where supports throughout the line are grounded, insulators which meet the requirements of Table 33 with one extra unit in each string normally requiring 5 or less and 2 extra units in each string normally requiring 6 or more; in all cases, the insulation at the crossing to be at least equal to that elsewhere in the line.

(c) Grounded Supports at Crossing Only. Insulator strings which have one extra unit where the strings in other portions of the line normally have 5 or less and 2 extra units where the strings elsewhere in the line have 6 or more units; in all cases the insulators to meet (b) above.

5. Insulators in Strain position. Where insulators are used in the strain position, one more unit than in 4 above to be used in each string.

6. Limit for Increased Number of Insulators. In no case is the application of the above paragraphs to result in the addition of more than 2 disks to strings normally requiring 5 or less, nor more than 3 disks to strings normally requiring 6 or more.

SECTION 128. MISCELLANEOUS REQUIREMENTS FOR OVERHEAD LINES

Order 1280. Supporting Structures.

A. *Poles and Towers.* 1. Rubbish. Poles and towers shall be placed, guarded, and maintained so as to be exposed as little as practicable to brush, grass, rubbish, or building fires.

2. Guarding Poles. (a) Protection Against Mechanical Injury. Where poles and towers are exposed to abrasian by traffic or to other damage which would materially affect their strength, they shall be protected by guards.

(b) Protection Against Climbing. On closely latticed poles or towers carrying supply conductors exceeding 300 volts to ground, either guards or warning signs shall be used except as follows: See 1214C.

Exception 1: Where the right of way is completely fenced.

Exception 2: Where the right of way is not completely fenced, provided the poles or towers are not adjacent to roads, regularly traveled thoroughfares, or places where people frequently gather, such as schools or public playgrounds.

3. Warning Signs. (a) On Poles or Towers. For warning signs on poles or towers, see Order 1280, A, 2, (b) and 1214C.

(b) On Bridge Fixtures. Structures attached to bridges for the purpose of supporting conductors shall be plainly marked with the name, initials, or trade-mark of the utility responsible for the attachment and, in addition, where the voltage exceeds 750 volts, by the following sign or its equivalent. "Danger—High Voltage" (See Orders 1214, C, 2 and 3).

4. Grounding Metal Poles. Metal poles not guarded or isolated shall always be specially grounded where in contact with metal-sheathed cable or the metal cases of equipment operating at voltages exceeding 750 volts.

Metal poles not guarded, isolated, or specially grounded should always be considered as imperfectly grounded and the insulators supporting line conductors as well as the strain insulators in attached span wires should, therefore, have a suitable margin of safety and be maintained with special care to prevent leakage to the pole as far as practicable.

5. Pole Steps. (a) Metal Steps. Steps closer than 6½ feet from the ground or other readily accessible place shall not be placed on poles.

(b) Wood Blocks. One wood block (or on private right of way more than one) may be placed on poles carrying communication cables or paired conductors below supply conductors; but the lowest block is not to be less than 3½ feet from the ground or other readily accessible place. On poles carrying only communication conductors, additional wood blocks may be used.

6. Identification of Poles. Poles, towers and other supporting structures on which are maintained electrical conductors shall be so constructed, located, marked, or numbered as to facilitate identification by employees authorized to work thereon. Date of installation of such structures shall be recorded where practicable by the owner.

7. Obstructions. All poles should be kept free from posters, bills, tacks, nails, and other unnecessary obstructions, such as through bolts not properly trimmed.

Exception: Because of the difficulty of maintaining stenciled signs on a creosoted surface, metal signs may be used on creosoted poles.

B. *Cross arms.* 1. Location. In general, cross arms should be maintained at right angles to the axis of the pole and to the direction of the attached conductors, and at crossings should be attached to that face of the structure away from the crossing, unless special bracing or double cross arms are used.

Note: Double cross arms are generally used at crossings, unbalanced corners, and dead ends in order to permit conductor fastenings at two insulators and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used and cross arm guys are sometimes used.

2. Bracing. Cross arms shall be securely supported, by bracing if necessary, so as to support safely loads to which they may be subjected, including linemen working on them. Any cross arm or buck arm, except the top one, shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

C. *Unusual Conductor Supports.* Where conductors are attached to structures other than those used solely or principally for supporting the lines, all rules shall be complied with as far as they apply and such additional precautions as may be deemed necessary by the administrative authority shall be taken to avoid injury to such structures or to the person using them. The supporting of conductors on trees and roofs should be avoided where practicable.

Order 1281. Tree Trimming.

A. *General.* Where trees exist near supply-line conductors, they shall be trimmed, if practicable, so that neither the movement of the trees nor the swinging or increased sagging of conductors in wind or ice storms or at high temperatures will bring about contact between the conductors and the trees. (See Sections 86.11, 86.12 and 86.16 of the 1933 Wisconsin Statutes).

Exception: For the lower-voltage conductors, where trimming is difficult, the conductor may be protected against abrasion and against grounding through the tree by interposing between it and the tree a sufficiently nonabsorptive and substantial insulating material or device.

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or other suitable construction.

Guys shall be used also, where necessary, wherever conductor tensions are not balanced, as at corners, angles, dead ends, and changes of grade of construction.

Note: This is to prevent undue increase of sags in adjacent spans as well as to provide sufficient strength for those supports on which the loads are considerably unbalanced.

B. *Strength.* The strength of the guy shall meet the requirements of Section 126 for the grade of construction that applies.

When guys are used with wood or other poles or towers capable of considerable deflection before failure, the guys shall be able to support the entire load in the direction in which they act, the pole acting simply as a strut.

C. *Point of Attachment.* The guy should be attached to the structure as near as practicable to the center of the conductor load to be sustained.

D. *Guy Fastenings.* Guys should be stranded and where attached to anchor rods should be protected by suitable guy thimbles or their equivalent. Cedar and other soft wood poles to which any guy having a strength of 10,000 pounds or more is attached should be protected by the use of suitable guy shims and, where there is a tendency for the guy to slip off the shim, guy hooks or other suitable means of preventing this action should be used. Shims are not necessary in the case of supplementary guys, such as storm guys.

E. *Guy Guards.* The ground end of all guys attached to ground anchors exposed to traffic shall be provided with a substantial and conspicuous wood or metal guard not less than 8 feet long.

Recommendation: It is recommended that in exposed or poorly lighted locations such guards be painted white or some other conspicuous color.

F. *Insulating Guys from Metal Poles.* Where anchors would otherwise be subject to electrolysis, guys attached to

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Note: Double cross arms are generally used at crossings, unbalanced corners, and dead ends in order to permit conductor fastenings at two insulators and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used and cross arm guys are sometimes used.

2. Bracing. Cross arms shall be securely supported, by bracing if necessary, so as to support safely loads to which they may be subjected, including linemen working on them. Any cross arm or buck arm, except the top one, shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

C. *Unusual Conductor Supports.* Where conductors are attached to structures other than those used solely or principally for supporting the lines, all rules shall be complied with as far as they apply and such additional precautions as may be deemed necessary by the administrative authority shall be taken to avoid injury to such structures or to the person using them. The supporting of conductors on trees and roofs should be avoided where practicable.

Order 1281. Tree Trimming.

A. *General.* Where trees exist near supply-line conductors, they shall be trimmed, if practicable, so that neither the movement of the trees nor the swinging or increased sagging of conductors in wind or ice storms or at high temperatures will bring about contact between the conductors and the trees. (See Sections 86.11, 86.12 and 86.16 of the 1933 Wisconsin Statutes).

Exception: For the lower-voltage conductors, where trimming is difficult, the conductor may be protected against abrasion and against grounding through the tree by interposing between it and the tree a sufficiently nonabsorptive and substantial insulating material or device.

B. *At Wire Crossings and Railroad Crossings.* The crossing span and the next adjoining spans shall be kept free, as far as practicable, from overhanging or decayed trees which might fall into the line.

Order 1282. Guying.

A. *Where Used.* When the loads to be imposed on poles, towers, or other supporting structures are greater than can safely be supported by the poles or towers alone, additional strength shall be provided by the use of guys, braces or other suitable construction.

Guys shall be used also, where necessary, wherever conductor tensions are not balanced, as at corners, angles, dead ends, and changes of grade of construction.

Note: This is to prevent undue increase of sags in adjacent spans as well as to provide sufficient strength for those supports on which the loads are considerably unbalanced.

B. *Strength.* The strength of the guy shall meet the requirements of Section 126 for the grade of construction that applies.

When guys are used with wood or other poles or towers capable of considerable deflection before failure, the guys shall be able to support the entire load in the direction in which they act, the pole acting simply as a strut.

C. *Point of Attachment.* The guy should be attached to the structure as near as practicable to the center of the conductor load to be sustained.

D. *Guy Fastenings.* Guys should be stranded and where attached to anchor rods should be protected by suitable guy thimbles or their equivalent. Cedar and other soft wood poles to which any guy having a strength of 10,000 pounds or more is attached should be protected by the use of suitable guy shims and, where there is a tendency for the guy to slip off the shim, guy hooks or other suitable means of preventing this action should be used. Shims are not necessary in the case of supplementary guys, such as storm guys.

E. *Guy Guards.* The ground end of all guys attached to ground anchors exposed to traffic shall be provided with a substantial and conspicuous wood or metal guard not less than 8 feet long.

Recommendation: It is recommended that in exposed or poorly lighted locations such guards be painted white or some other conspicuous color.

F. *Insulating Guys from Metal Poles.* Where anchors would otherwise be subject to electrolysis, guys attached to

metal poles or structures and not containing guy insulators should be insulated from the metal pole or structure by suitable blocking.

G. *Anchor Rods.* Anchor rods shall be installed so as to be in line with the pull of the attached guy when under load, except in rock or concrete. The anchor rod shall have an ultimate strength in the eye and shank equal to that required of the guy.

H. *Grounding.* The anchored end of guys attached to wood poles carrying circuits of more than 15,000 volts shall be permanently grounded (see section 103 for method) wherever this part of the guy has a clearance of less than 8 feet to ground.

Exception 1: This does not apply to guys in rural districts.
Exception 2: This does not apply if the guy contains an insulator which will meet the requirements of Order 1283, A, 2 for the highest voltage liable to be impressed on it.

Order 1283. Guy Insulators.

A. *Properties of Guy Insulators.* 1. Material. (a) Grades A and B. Guy insulators shall be made by the wet-porcelain process or a process equally suitable as regards electrical and mechanical properties.

(b) Grades C, D, E, and N. No requirements are made for material.

2. Electrical Strength. Guy insulators shall have a dry flash-over voltage at least double the normal line voltage and a wet flash-over voltage at least as high as the normal line voltage between conductors.

3. Mechanical Strength. Guy insulators shall have a mechanical strength at least equal to that required of the guys in which they are installed.

B. *Use of Guy Insulators.* 1. One Insulator. An insulator shall be located in each guy which is attached to a pole or structure carrying any supply conductors of more than 300 volts to ground and not more than 15,000 volts between conductors, or in any guy which is exposed to such voltages. This guy insulator shall be located from 8 to 10 feet above the ground.

Exception: A guy insulator is not required where the guy is grounded under the conditions set forth in 4 following.

2. Two insulators. Where a guy attached to any pole carrying communication or supply conductors or both, is carried over or under overhead supply conductors of more than 300 volts to ground and where hazard would otherwise exist, two or more guy insulators shall be placed so as to include the exposed section of the guy between them as far as possible. Neither insulator shall be within 8 feet of the ground.

Exception: These insulators are not required where the guy is grounded under the conditions set forth in 4 following.

3. Relative Location of Insulators in Guys located One Above the Other. Where guys in which it is necessary to install insulators are so arranged that one crosses or is above another, insulators shall be so placed that in case any guy sags down upon another the insulators will not become ineffective.

4. Conditions not Requiring Guy Insulators. Insulators are not required in guys under the following conditions:

(a) Where the guy is electrically connected to grounded steel structures or to a ground connection on wood poles.

(b) Where the guys are uniformly permanently grounded throughout any system of overhead lines.

Order 1284. Span-Wire Insulators.

A. *Mechanical Strength.* Span-wire insulators shall have a mechanical strength at least equal to that required of the span wire in which they are installed.

B. *Use of Span-Wire Insulators.* All span wires, including bracket span wires, shall have a suitable strain insulator (in addition to an insulated hanger if used) inserted between each point of support of the span wire and the lamp or trolley contact conductor supported, except that single insulation, as provided by an insulated hanger, may be permitted when the span wire or bracket is supported on wooden poles supporting only trolley, railway feeder, or communication conductors used in the operation of the railway concerned. In case insulated hangers are not used, the strain insulator shall be located so that in the event of a broken span wire the energized part of the span wire can not be reached from the ground.

Exception: This rule does not apply to insulated feeder taps used as span wires.

Order 1285. Conductors.

A. *Identification.* All conductors of electrical supply and communication lines should be arranged to occupy definite positions throughout, as far as practicable, or shall be so constructed, located, marked, or numbered as to facilitate identification by employees authorized to work there-

on. This does not prohibit systematic transposition of conductors.

B. *Branch Connections.* 1. Accessibility. Connections of branches to supply circuits, service loops, and equipment in overhead construction shall be readily accessible to authorized employees. When possible, connections shall be made at poles or other structures.

2. Clearance. Branch connections shall be supported and placed so that swinging or sagging cannot bring them in contact with other conductors, or interfere with the safe use of pole steps, or reduce the climbing or lateral working space.

Order 1286. Equipment on Poles.

A. *Identification.* All equipment of electrical supply and communication lines should be arranged to occupy definite positions throughout, as far as practicable, or shall be constructed, located, marked, or numbered so as to facilitate identification by employees authorized to work thereon.

B. *Location.* Transformers, regulators, lightning arresters, and switches when located below conductors or other attachments shall be mounted outside of the climbing space. This equipment shall be so placed that the conductors entering the equipment will have the proper clearance from ground.

C. *Guarding.* Current-carrying parts of switches, automatic circuit-breakers, and lightning arresters shall be suitably inclosed or guarded if all the following conditions apply.

1. If of more than 300 volts to ground, and,
2. If located on the climbing side of the pole less than 20 inches from the pole center, and,
3. If located below the top cross arm.

D. *Hand Clearance.* All current-carrying parts of switches, fuses, lightning arresters, also transformer connections and other connections which may require operation or adjustment while alive and are exposed at such times, shall be arranged so that in their adjustment while alive the hand need not be brought nearer to any other current-carrying part at a different voltage than the clearances from pole surfaces required in Table 9, Order 1235, A, 3, (a), for conductors of corresponding voltages. (See also Orders 1422 A, B, and C.)

E. *Street-Lighting Equipment.* 1. Clearance from Pole Surface. All exposed metal parts of lamps and their supports (unless effectively insulated from the current-carrying parts) shall be maintained at the following distances from the surface of wood poles:

	Inches
(a) In general	20
(b) If located on the side of the pole opposite the designated climbing side	5

Exception: This does not apply where lamps are located at pole tops.

2. Clearance Above Ground. Street lamps shall be mounted at not less than the following heights above ground.

	Feet
(a) Over walkways	10
(b) Over roadways—	
Connected to circuits of 150 volts or less	14
Connected to circuits of more than 150 volts	15

Note: Drops to street lights need have no greater clearance than the street lights themselves.

3. Horizontal Clearances. Arc and incandescent lamps in series circuits should have at least 3 feet horizontal clearance from windows, porches, and other spaces accessible to the general public.

4. Material of Suspension. The lowering rope or chain for lighting units arranged to be lowered for examination or maintenance shall be of a material and strength designed to withstand climatic conditions and to sustain the lighting unit safely. The lowering rope or chain, its supports, and fastenings shall be examined periodically.

5. Insulators in Suspension Ropes. Effective insulators as specified in Order 1283, A, should be inserted at least 8 feet from the ground in metallic suspension ropes or chains supporting lighting units of series circuits.

6. Arc-Lamp Disconnectors. A suitable device shall be provided by which each arc lighting unit on series circuits of more than 300 volts to ground may be safely and entirely disconnected from the circuit before the lamp is handled unless the lamps are always worked on from suitable insulating stools, platforms, or tower wagons, or handled with suitable insulating tools, and treated as under full voltage of the circuit concerned.

Order 1287. Protection For Exposed Communication Lines.

A. *Open Wire.* Communication lines for public use and fire-alarm lines shall be treated as follows if at any point they are exposed to supply (including trolley) lines of more than 400 volts to ground.

1. At stations for public use they shall be protected by one of the methods specified in part 3, section 136.0.

2. Elsewhere they shall be isolated by elevation or otherwise guarded so as to be inaccessible to the public.

B. *Metal-Sheathed Cable.* Metal-sheathed cables and messengers shall be isolated or grounded in conformity with the general requirements of section 121.

Order 1288. Communication Circuits Used Exclusively in the Operation of Supply Lines.

A. *Choice of Method.* Communication circuits used exclusively in the operation of supply lines may be run either as ordinary communication circuits or as supply circuits under the conditions specified in Order 1288, C and D, respectively. After selection of the type of communication-circuit construction and protection for any section which is isolated, or is separated by transformers, such construction and protection shall be consistently adhered to throughout the extent of such isolated section of the communication system.

B. *Guarding.* Communication circuits used in the operation of supply lines shall be isolated by elevation or otherwise guarded at all points so as to be inaccessible to the public.

C. *Where Ordinary Communication Line Construction May Be Used.* Communication circuits used in the operation of supply lines may be run as ordinary communication conductors under the following conditions:

1. Where such circuits are below supply conductors in the operation of which they are used (including high voltage trolley feeders) at crossings, conflicts, or on commonly used poles, provided:

(a) Such communication circuits occupy a position below all other conductors or equipment at crossings, conflicts or on commonly used poles.

(b) Such communication circuits and their connected equipment are adequately guarded and are accessible only to authorized persons.

(c) The precautions of orders 1360.07 & 1360.08 and Section 144 of Part 4 have been taken.

2. Where such circuits are below supply conductors in the operation of which they are used and are above other supply or communication conductors at wire crossings, conflicts, or on the same poles, provided the communication circuits are protected by fuseless lightning arresters, drainage coils, or other suitable devices to prevent the communication circuit voltage from normally exceeding 400 volts to ground.

Note: The grades of construction for communication conductors with inverted levels apply.

D. *Where Supply Line Construction Must Be Used.* Communication circuits used in the operation of supply lines shall comply with all requirements for the supply lines with which they are used, where they do not comply with the provisos of C, 1 above or the proviso of C, 2 above.

Exception 1: Where the voltage of the supply conductors concerned exceeds 7,500, the communication conductors need only meet the requirements for a 7,500-volt supply circuit.

Exception 2: Where the supply conductors are required to meet grade C, the size of the communication conductors may be the same as for grade D (see Order 1262, I, 2) for spans up to 150 feet.

Order 1289. Electric Railway Construction.

A. *Trolley Contact Conductor Supports.* All overhead trolley contact conductors shall be supported and arranged so that the breaking of a single contact conductor fastening will not allow the trolley-conductor, live span wire, or current-carrying connection to come within 10 feet (measured vertically) from the ground, or from any platform accessible to the general public.

Span-wire insulation for trolley contact conductors shall comply with Order 1284.

B. *High-Voltage Contact Conductors.* Every trolley contact conductor of more than 750 volts in urban districts where not on fenced right of way shall be suspended so as to minimize the liability of a break, and, as far as practicable, so that if broken at a single point, it cannot fall within 12 feet (measured vertically) from the ground or any platform accessible to the general public.

C. *Third Rails.* Third rails shall be protected where not on fenced rights of way by adequate guards composed of wood or other suitable material.

D. *Prevention of Loss of Contact at Railroad Crossings.* Trolley contact conductors shall be arranged as set forth in either 1 or 2 following, at grade crossings with interurban or other heavy-duty or high-speed railroad systems.

1. The trolley contact conductor shall be provided with live trolley guards of suitable construction, or,

2. The trolley contact conductor shall be as far as practicable at the same height above its own track throughout the crossing span and the next adjoining spans. Where a uniform height above rail is not adhered to, the change shall be made in a very gradual manner. Where the crossing span exceeds 100 feet, catenary construction shall be used.

Exception: This rule does not apply where the system is protected by interlocking derails or by gates.

E. *Guards Under Bridges.* 1. Where Guarding is Required. Guarding is required where the trolley contact conductor is so located that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

2. Nature of Guarding. Guarding shall consist of a substantial inverted trough of nonconducting material located above the contact conductor, or other suitable means of preventing contact between the trolley pole and the bridge structure.

SECTION 129. ORDERS FOR UNDERGROUND LINES

Order 1290. Location of Duct Systems and Manholes.

A. *General Location.* Underground systems of electrical conductors should be located so as to be subject to the least practicable disturbance. All railway tracks and all underground structures, including catch basins, gas pipes, etc., should be avoided where practicable. Conductors and cables carried underground under railways shall be placed in suitable ducts.

B. *Ducts.* The ducts between adjacent manholes or other outlets should be installed in straight lines. If curves are necessary, they should be of the longest practicable radius, and the spacing between adjacent manholes should be reduced proportionately.

C. *Manholes.* Manholes shall, where practicable, be located so as to provide convenient access and so that the least horizontal distance from any track rail to the nearest edge of the manhole opening will be not less than 3 feet. At crossings under railroads, manholes, pull boxes, and terminals shall be located away from the roadbed (preferably outside the fenced right of way).

Order 1291. Construction of Duct Systems.

A. *Material, Size, and Finish of Ducts.* Ducts shall be of such material, size, mechanical strength, and finish as to facilitate the installation and maintenance of conductors or cables. Ducts shall be freed from burrs before laying and shall have clear bores.

B. *Grading of Ducts.* Grade of ducts shall be such as to drain toward manholes or handholes. A grade of not less than 3 inches in 100 feet of length shall be provided where practicable.

C. *Alinement of Ducts.* Ducts shall be laid so as to prevent inside shoulders at joints.

D. *Duct Joints.* Joints in duct runs shall be made mechanically secure to maintain individual ducts in alinement.

E. *Protection.* 1. Settling. Ducts should be suitably reinforced or be laid on suitable foundations of sufficient mechanical strength where necessary to protect them from settling.

2. Damage. Ducts should be protected by concrete or other covering where necessary to prevent being damaged by workmen when digging, or by other causes.

F. *Clearances.* 1. General. The clearances between duct systems and other underground structures, particularly gas lines paralleling them, shall be as great as practicable. The distance between the top covering of the duct system and the pavement surface, or other surface under which the duct system is constructed, shall be sufficient to protect the duct system from injury.

2. Railroad Tracks. The distance between the top of the duct system structure and the base of the rail shall be not less than 30 inches in the case of street railways and not less than 42 inches in the case of steam and electric railroads.

Exception 1: Where the ballast section subject to working and cleaning is less than 42 inches, the clearance may be reduced for street railways to not less than 18 inches; and for steam and electric railroads to not less than 30 inches; but in no case to less than the depth of ballast section plus 6 inches. In lieu of the additional depth of 6 inches, a 1½-inch creosoted plank, or 3 inches of concrete, or iron pipe may be provided.

Note: The above clearances are based on a duct system, the width of which is not more than 3 creosoted wood ducts, 4 vitrified clay ducts, 4 impregnated fiber ducts or 4 iron or mild steel pipes. These clearances do not apply to bridge-type structures designed to sustain the weight of the roadbed and the operating load.

When a wider duct system is contemplated, additional strength of construction and protection should be provided, or the duct system should be placed at greater depth.

Where unusually hard digging, as in rock, or when obstructions are encountered, a conduit run may be spread to a width of six ducts, so as to maintain the required clearance beneath the base of the rail.

Exception 2: Where physical and chemical conditions will permit a duct system consisting of not more than two iron pipes, not exceeding 3 inches in diameter, or two creosoted wood ducts, not exceeding 4½ inches square, used for communication lines or for service supply lines not exceeding 750 volts, may be laid in the ground beneath the tracks without any other form of protection at a depth not less than 18 inches below the base of the rail unless the worked ballast section of the roadbed exceeds 18 inches, in which case the duct system shall be laid below the ballast section.

G. *Separation Between Supply and Communication Duct Systems.* 1. General. Duct systems, including laterals, to be occupied by communication conductors for public use should be separated, where practicable, from duct systems, including laterals, for supply conductors by not less than 3 inches of concrete, 4 inches of brick masonry, or 12 inches of well-tamped earth.

Exception: Extensions may, however, be made to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, communication companies, or power companies with less effective separations than above specified.

2. Entering Manholes. Where communication conductors and supply conductors occupy ducts terminating in the same manhole, the two classes of ducts should be separated as widely as practicable and where practicable should enter the manhole at opposite sides.

Explanation: This requirement is made so that cables can be racked along side walls with a minimum of crosses between the two classes of conductors.

H. *Duct Entrances into Manholes.* 1. Clearances. Duct entrances into manholes should, where practicable, have a clearance above the floor or below the roof line of not less than 6 inches, and from either side wall of at least 4 inches.

2. Smooth Outlet. Iron pipe conduit terminating in manholes, handholes, or other permanent openings of underground systems, shall be provided with an effective shield, bushing or other smooth outlet.

I. *Sealing Laterals.* Lateral ducts for service connections to buildings, through which gas or water may enter buildings or other duct systems should be effectively plugged or cemented by the use of asphaltum, pitch, or other suitable means.

J. *Duct Arrangement for Dissipation of Heat.* Duct systems intended to carry supply cables of large current capacity should be arranged where practicable, so that ducts carrying such cables, will not dissipate their heat solely through other ducts.

Order 1292. Construction of Manholes.

A. *Minimum Strength.* The design and construction of manholes and handholes shall provide sufficient strength to sustain, with a suitable margin of safety, the loads which may reasonably be imposed on them.

B. *Dimensions.* Manholes should meet the following requirements where practicable:

1. Width. The least horizontal inside dimension should be not less than 3 feet 6 inches.

2. Working Space. A clear working space should be provided. The horizontal dimension should be not less than 3 feet. The vertical dimension should be not less than 6 feet except in manholes where the opening is within 1 foot on each side of the full size of the manhole.

Exception: The dimensions specified in 1 and 2 above are not necessary in service boxes, handholes, or in manholes serving a small number of ducts, or in manholes used exclusively for communication system equipment and cables.

C. *Drainage.* Where drainage is into sewers, suitable traps shall be provided to prevent entrance of sewer gas into manholes.

D. *Ventilation.* Adequate ventilation to open air shall be provided for manholes from which any openings exist into subways entered by the public.

Exception: Subways under water or in other locations where it is impracticable to comply.

E. *Manhole Openings.* The opening to any manhole should be not less than 24 inches minimum dimension.

Recommendation: Round openings are recommended.

F. *Manhole Covers.* Manholes and handholes, while not being worked in, shall be securely closed by covers of sufficient strength to sustain such loads as reasonably may be imposed upon them.

G. *Supports for Cables.* Supports shall be provided, where necessary, for all cables at each manhole, handhole, or other permanent opening.

Note: In handholes which reach the top line of ducts only, or in small manholes, the duct line itself may serve as sufficient support for the cables.

Order 1293. Manhole Location.

Manhole openings shall, where practicable, be located so that barriers or other suitable guards can be placed to protect the opening effectively when uncovered.

Order 1294. Location of Conductors.

A. *Accessibility.* Cables in manholes shall be reasonably accessible from the clear working space at all times. When cables pass by or cross over other cables, sufficient clearance shall be provided between them to prevent abrasion and to permit reasonable access to any cable for inspection or repair.

B. *Clearance from Manhole Floor.* Each cable shall be maintained at a vertical clearance above the manhole floor of at least 6 inches, where practicable.

C. *Conductors Carrying Large Currents.* Conductors intended to carry large currents should be located, where practicable, in outside ducts so that they will not necessarily dissipate heat solely through adjacent ducts.

D. *Separation Between Conductors.* 1. Cables of Different Voltages. Cables shall be arranged and supported in ducts and manholes so that those operating at higher voltages will be separated as far as practicable from those operating at lower voltages.

2. Cables of Different Systems. Cables belonging to different systems, particularly supply distribution and communication systems, shall not be installed in the same duct run.

3. Conductors of Supply and Communication Systems. (a) General. Supply Conductors and communication conductors for public use should, in general, be maintained in separate duct systems, and particularly in separate manholes.

Exception: Cable extensions may be made to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, communication companies or power companies.

(b) In the Same Manhole. Supply conductors and communication conductors for public use occupying the same manhole should be maintained at opposite sides of the manhole.

Where supply and communication cables must cross, a separation of at least 1 foot shall be maintained.

Order 1295. Protection of Conductors in Duct Systems and Manholes.

A. *Protection Against Moisture.* Cables shall be provided with a water-tight metal sheath or other waterproof covering over their insulating coverings.

Exception: This requirement does not apply to rubber-insulated cables nor to cables used as ground connections or neutrals.

B. *Protection Against Arcing.* A suitable fire-resisting covering should be placed on the following cables to prevent injury from arcing:

1. Closely grouped lead-sheathed supply cables of more than 7,500 volts, or of large-current capacity operating at more than 750 volts a. c. or 300 volts d. c.

2. Communication cables and supply cables of large current capacity if they are within the same manhole and within arcing distance of each other.

3. Communication cables and supply cables which cross each other in the same manhole. In this case the protective covering above specified is mandatory.

C. *Mechanical Protection.* 1. Crossings of Supply and Communication Cables. Special mechanical protection shall be provided against abrasion where supply and communication conductors must cross in the same manhole.

2. Iron Pipe Conduit. Iron pipe conduit, terminating in manholes, handholes, or other permanent openings of underground systems, shall be provided with an effective shield, bushing, or other smooth outlet.

Order 1296. Guarding of Live Parts in Manholes.

A. *Conductor Joints or Terminals.* Joints or terminals of conductors or cables of supply systems shall be arranged so that there are no bare ungrounded current-carrying metal parts exposed to accidental contact within manholes or handholes.

B. *Apparatus.* 1. General. Live parts of protective, control, or other apparatus of supply lines installed and maintained in manholes or handholes shall be inclosed in suitable grounded cases.

2. Continuity Between Cable Sheath and Apparatus Cases. The metal sheathing of all conductors or cables shall be made mechanically and electrically continuous with the metal cases of protective, control, or other apparatus.

Order 1297. Construction at Risers from Underground.

A. *Separation Between Risers of Communication and Supply Systems.* The placing of risers for communication systems and risers for supply systems on the same pole should be avoided where practicable. If it is necessary to use the same pole for the risers of both systems, they shall be placed on opposite semicircumferences of the pole where practicable.

B. *Mechanical Protection of Conductors.* All conductors or cables from underground systems which connect to overhead systems shall be protected by a covering which gives suitable mechanical protection up to a point 8 feet above the ground.

Exception 1: Armored cables or cables installed in a grounded metal conduit.

Exception 2: Communication circuits on private fenced rights of way.

C. *Grounding of Riser Pipes.* Exposed metal riser pipes containing supply conductors shall be grounded unless such conductors are covered with a grounded metal sheath or are themselves grounded.

D. *Conductor Terminal Construction.* The terminals of underground cables operating at more than 750 volts to ground and connecting to overhead open-wire systems shall meet the following requirements:

1. Protection Against Moisture. Protection shall be provided so that moisture will not enter the cable.

2. Insulation of Conductors. Conductors shall be properly insulated from the grounded metal sheath. In addition, the conductors of multiple conductor cable shall be properly separated and insulated from each other.

Note: These requirements may be fulfilled by the use of potheads or other equivalent devices, such as oil switches, if incidentally they accomplish the same purpose.

E. *Clearance Above Ground for Open Supply Wiring.* Supply wires connecting to underground systems shall not be run open closer to the ground than is indicated by the following table:

TABLE 34

Clearance Above Ground for Open Supply Wiring

Voltage		
0 to 750 volts	750 to 15,000 volts	Exceeding 15,000 volts
Feet 14	Feet 16	Feet 18

Order 1298. Identification of Conductors.

Cables shall be permanently identified by tags or otherwise at each manhole, handhole, or other permanent opening of the underground system.

Exception: This requirement does not apply where the position of a cable, in conjunction with diagrams supplied to workmen, gives sufficient identification, or where the manhole is occupied solely by the communication cables of one utility.

Order 1299. Identification of Apparatus Connected in Multiple.

Where transformers, regulators, or other similar apparatus not located in the same manhole operate in multiple, special tags, diagrams, or other suitable means shall be used to indicate that fact.

Exception: This requirement does not apply where disconnecting devices are provided to permit cutting such equipment completely off the system.

Appendices of Part 2

Appendix A—Minimum Permissible Sags for Line Conductors of Grades A, B, and C, and Corresponding Tensions

Sags of line conductors of different materials at 30, 60, and 90° F. have been computed, such that when loaded the resulting tension in the conductor will equal 50 per cent of its ultimate strength for grades A and B, and 60 per cent for grade C (see Order 1261, F, 4).

Tables 35 to 37 present values of the sag in the conductor for various spans for hard-drawn and medium copper; Table 38 for soft copper; Tables 39 to 44 for three grades of steel; Tables 45 and 46 for copper-covered steel designated as standard grade; Table 47 for aluminum; and Table 48 for aluminum cable with steel core. Tables 49 to 62 give the corresponding stringing tensions in the various conductors.

The properties of the various conductors involved in the computation of sags and tensions are given in Appendix C. These sags and tensions are not applicable to conductor materials having properties which differ considerably from the values on which the tables are based. When such materials are used, the sags and tensions should be based upon the actual properties of the material concerned.

TABLE 35

Sags for Medium and Hard-Drawn Bare Solid Copper Wire

HEAVY LOADING DISTRICT

(The sags being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Sag (inches) for span lengths (feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	4.4¾	15.6	36.5	------	------	------	------	------	------
		60	6.5	20.4	40.7	------	------	------	------	------	------
		90	9.7	24.6	44.5	------	------	------	------	------	------
6	A and B	30	4.4	12.3¾	27.7¾	------	------	------	------	------	------
		60	6.5	16.9	32.8	------	------	------	------	------	------
		90	9.7	21.6	37.1	------	------	------	------	------	------
	C	30	2.6	5.1	10.6¾	22.7	------	------	------	------	------
		60	3.1	6.8	14.8	28.6	------	------	------	------	------
		90	4.1	9.4	19.8	34.2	------	------	------	------	------
4	A and B	30	3.0	5.5	10.6	19.3	33.1	66.6	109	------	------
		60	3.8	7.7	14.6	25.2	39.1	72.3	115	------	------
		90	5.3	10.8	19.6	31.5	45.1	78.4	121	------	------
	C	30	2.2	3.6	6.1	9.4	15.1	37.2	71.0	------	------
		60	2.6	4.5	7.2	11.9	19.4	44.7	79.0	------	------
		90	3.1	5.7	9.5	16.2	25.2	52.2	86.0	------	------
2	A and B	30	2.9	4.8	7.6	11.8	17.8	38.4	67.0	142	238
		60	3.5	6.2	9.7	15.5	23.0	45.6	74.5	150	252
		90	4.8	8.3	13.3	20.6	29.5	53.1	82.4	158	260
	C	30	2.1	3.4	5.4	7.6	11.0	21.0	38.9	97	172
		60	2.6	4.2	6.5	9.5	13.4	26.4	46.8	106	191
		90	3.1	5.3	7.9	11.8	17.3	33.3	55.4	117	202
1	A and B	30	2.9	4.6	7.0	10.5	15.4	30.6	53.6	118	203
		60	3.5	6.0	9.0	13.6	20.1	37.8	62.6	127	212
		90	4.8	7.9	12.4	18.1	25.4	45.6	70.6	135	220
	C	30	2.2	3.3	5.0	7.6	10.1	18.3	31.7	77.8	148
		60	2.6	3.9	6.5	9.0	12.5	22.8	38.9	88.4	157
		90	3.2	5.2	7.9	11.3	15.8	28.8	46.8	98.4	168
0	A and B	30	2.8	4.5	6.8	10.1	14.1	26.4	45.3	99.8	173
		60	3.5	6.0	9.0	13.0	18.2	33.6	53.2	109	184
		90	4.8	7.9	12.2	17.2	23.7	40.2	61.9	119	193
	C	30	2.2	3.3	5.2	7.6	10.1	17.4	28.4	65.8	122
		60	2.6	4.2	6.5	8.8	12.5	21.6	34.9	75.8	135
		90	3.4	5.3	7.9	11.6	15.6	26.7	42.5	86.4	146
00	A and B	30	2.9	4.8	6.8	9.6	13.7	24.6	40.0	86.9	152
		60	3.7	6.0	9.0	12.6	17.7	30.6	47.9	97.0	163
		90	5.0	8.1	11.9	16.8	23.0	37.5	56.5	107	171
	C	30	2.3	3.6	5.2	7.6	10.1	16.8	26.6	58.1	106
		60	2.8	4.3	6.3	9.0	12.2	21.0	32.4	68.2	117
		90	3.4	5.4	8.1	11.3	15.1	26.1	39.6	77.8	129
0000	A and B	30	3.1	5.0	7.2	10.1	13.2	22.8	35.7	71.1	121
		60	4.1	6.5	9.4	13.0	17.3	28.8	43.2	81.6	133
		90	5.5	8.7	12.8	17.0	22.3	35.7	51.8	91.2	144
	C	30	2.5	3.9	5.6	7.8	10.1	16.8	25.2	50.9	88.8
		60	3.0	4.8	6.8	9.5	12.7	20.4	30.6	60.0	101
		90	3.8	6.2	8.6	11.8	15.9	26.1	37.8	69.2	112

TABLE 36

Sags for Medium and Hard-Drawn Bare Stranded Copper Wire

HEAVY LOADING DISTRICT

(The sags being such that when loaded at 0 ° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Sags (inches) for span lengths (feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	2.9	5.4	10.4	32.6	67.2	------	------	------	------
		60	3.6	7.2	14.4	39.4	72.6	------	------	------	------
		90	5.0	10.2	19.4	45.1	79.2	------	------	------	------
	C	30	2.2	3.6	5.7	14.9	36.0	------	------	------	------
		60	2.6	4.2	7.2	19.2	43.8	------	------	------	------
		90	3.1	5.4	9.4	25.0	51.6	------	------	------	------
2	A and B	30	2.6	4.5	7.2	16.8	36.0	99.1	240	------	------
		60	3.4	5.7	9.4	22.1	43.8	107.0	248	------	------
		90	4.3	7.8	13.0	28.3	51.6	115.0	256	------	------
	C	30	2.2	3.3	5.0	10.1	19.8	62.2	176	------	------
		60	2.4	3.9	5.7	12.5	25.2	72.2	186	------	------
		90	2.9	4.8	7.5	15.8	31.2	81.5	196	------	------
1	A and B	30	2.6	4.5	6.8	14.9	31.2	82.3	203	438	------
		60	3.4	5.7	9.0	19.7	36.6	96.7	212	447	------
		90	4.6	7.5	11.9	25.0	44.4	100.0	221	454	------
	C	30	2.2	3.3	5.0	10.1	17.4	51.2	146	338	761
		60	2.6	3.9	6.1	12.0	23.4	59.6	157	348	770
		90	3.1	5.1	7.9	15.4	27.6	69.7	167	358	780
0	A and B	30	2.6	4.2	6.5	12.5	23.4	63.0	161	349	787
		60	3.1	5.4	7.9	15.8	29.4	72.2	172	368	797
		90	4.3	6.9	10.8	21.1	37.2	82.3	181	378	806
	C	30	2.2	3.3	5.0	9.1	15.6	38.6	113	270	624
		60	2.4	3.9	5.8	11.0	19.8	47.0	119	282	634
		90	2.9	4.8	6.8	13.4	23.4	50.4	137	296	648
00	A and B	30	2.6	4.2	6.5	12.5	21.6	54.6	140	307	682
		60	3.4	5.4	7.9	15.4	27.0	63.8	144	319	691
		90	4.3	7.2	10.4	20.2	33.6	73.1	149	331	698
	C	30	2.2	3.3	4.7	9.1	15.0	36.1	96	232	535
		60	2.6	3.9	5.8	10.6	18.0	42.8	107	245	547
		90	3.1	4.8	7.2	13.0	22.2	51.2	120	259	562
0000	A and B	30	2.6	4.2	6.1	11.5	18.6	42.0	102	222	506
		60	3.1	5.1	7.6	13.9	22.8	50.4	114	244	523
		90	4.3	6.9	9.7	18.2	28.8	58.8	126	257	535
	C	30	2.2	3.3	4.7	8.6	13.8	30.2	73	160	396
		60	2.6	3.9	5.7	10.0	16.8	36.1	84	176	413
		90	3.1	4.8	6.8	12.5	21.0	43.7	96	188	432

TABLE 37

Sags for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire

HEAVY LOADING DISTRICT

(The sags being such that when loaded at 0 ° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Sags (inches) for span lengths (feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	C	30	10.2	29.7	50.4				
		60	13.3	31.5	53.6				
		90	17.2	35.1	56.6				
6	A and B	30	8.7	23.1	37.1				
		60	12.2	26.6	44.7				
		90	15.6	30.6	48.1				
	C	30	4.1	9.7	22.5	38.9			
		60	5.4	12.7	27.7	44.1			
		90	7.2	16.9	32.0	48.5			
4	A and B	30	4.4	9.6	18.4	32.8	48.7		
		60	6.1	12.4	23.0	38.0	54.2		
		90	8.2	16.6	28.1	42.9	58.8		
	C	30	2.9	5.3	9.2	16.2	26.4		
		60	3.7	6.6	11.5	20.2	32.6		
		90	4.6	8.4	15.1	25.4	38.9		
2	A and B	30	3.8	6.6	11.2	18.7	28.3	55.5	90.0
		60	5.0	8.7	14.8	23.1	34.1	62.4	97.2
		90	6.5	11.5	18.9	28.6	40.1	68.4	104
	C	30	3.0	4.8	7.4	11.3	16.3	33.3	60.2
		60	3.5	5.7	9.0	14.3	20.1	39.6	67.4
		90	4.3	7.1	11.5	17.2	25.0	46.2	75.6
1	A and B	30	3.6	6.1	9.7	15.5	22.6	44.4	73.4
		60	4.6	7.8	12.6	19.7	38.1	52.2	81.8
		90	6.2	10.8	16.7	24.6	34.1	58.2	88.2
	C	30	2.8	4.6	6.8	10.1	13.9	27.3	46.1
		60	3.2	5.5	8.5	12.2	17.7	33.6	55.1
		90	4.2	6.9	10.6	15.7	21.8	40.2	62.3
0	A and B	30	3.7	6.0	9.4	14.1	20.6	38.4	62.6
		60	4.8	7.8	12.1	17.8	25.4	45.0	70.6
		90	6.4	10.6	15.6	22.9	31.2	52.8	78.2
	C	30	2.8	4.6	6.8	9.9	13.7	24.6	41.0
		60	3.5	5.5	8.1	12.2	16.8	30.3	48.6
		90	4.4	6.7	10.1	14.9	20.9	35.7	55.8
00	A and B	30	3.6	6.0	9.0	13.2	18.5	33.6	54.0
		60	4.6	7.8	11.5	16.8	23.0	39.9	61.9
		90	6.1	10.5	15.1	21.4	28.5	46.8	70.9
	C	30	2.6	4.6	7.0	9.7	13.2	22.8	36.0
		60	3.2	5.5	8.3	11.8	16.1	27.6	43.6
		90	4.2	6.9	10.4	14.5	20.1	33.6	50.8
0000	A and B	30	3.7	6.0	9.0	12.6	17.5	28.8	45.0
		60	4.8	7.8	11.5	16.2	21.1	34.8	53.3
		90	6.6	10.5	15.1	20.4	27.1	42.0	61.2
	C	30	2.9	4.6	6.8	9.7	12.7	20.4	32.4
		60	3.6	5.7	8.5	11.8	15.6	25.5	38.9
		90	4.6	7.4	10.4	14.5	19.7	30.9	45.7

TABLE 38

Sags for T. B. W. P. Solid Soft Copper Wire

HEAVY LOADING DISTRICT

(The sags being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Sags (inches) for span lengths (feet) of					
			100	125	150	175	200	250
		°F.						
6	C	30	29.1	50.2	76.9			
		60	31.4	52.8	78.9			
		90	33.6	55.2	81.0			
4	A and B	30	22.8	39.3	60.1			
		60	25.8	42.5	62.8			
		90	28.4	45.3	65.5			
	C	30	14.5	28.3	45.5			
		60	18.1	32.0	48.9			
		90	21.6	35.0	50.4			
2	A and B	30	12.4	22.9	37.1	53.4	72.8	
		60	16.1	27.3	41.2	58.0	76.3	
		90	19.7	30.9	45.0	61.4	80.6	
	C	30	7.2	14.2	25.1	38.7	55.0	
		60	10.1	18.6	30.2	43.9	59.3	
		90	14.0	23.1	34.7	48.3	63.8	
1	A and B	30	9.6	17.9	28.8	43.3	58.1	
		60	12.6	22.5	33.6	47.9	63.6	
		90	17.0	26.2	37.8	52.3	68.4	
	C	30	6.0	10.9	18.4	29.8	42.2	
		60	8.0	14.7	23.8	34.9	48.0	
		90	11.7	19.2	28.4	40.3	53.6	
0	A and B	30	7.8	14.4	23.6	35.3	48.2	
		60	11.3	18.9	28.3	40.5	53.3	
		90	15.0	23.1	33.1	45.0	57.2	
	C	30	5.4	9.4	15.5	23.9	34.6	
		60	7.4	12.9	20.2	29.4	40.1	
		90	10.6	16.8	25.0	34.4	45.8	
00	A and B	30	6.8	12.0	19.1	28.8	39.8	
		60	9.6	16.2	24.3	34.0	45.6	
		90	13.6	20.5	28.8	39.5	51.4	
	C	30	4.8	8.3	13.0	19.3	27.6	
		60	6.6	11.2	17.5	24.4	33.3	
		90	9.5	15.3	22.0	30.3	40.1	
0000	A and B	30	5.8	9.6	14.8	21.4	28.8	
		60	8.2	13.3	19.3	26.7	35.3	
		90	11.3	17.4	24.5	32.8	40.8	
	C	30	4.4	7.2	10.8	15.5	20.6	
		60	5.9	9.7	14.2	20.0	26.4	
		90	8.5	13.3	18.5	25.2	32.2	

TABLE 39

Sags for Ordinary Grade Steel Wire

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the sags being such that when loaded at 0°F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C.)

Steel Wire Gage No.	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	4.1	12.5	26.0	------	------	------	------	------	------
		60	6.2	16.5	30.0	------	------	------	------	------	------
		90	11.1	20.0	33.5	------	------	------	------	------	------
6	A and B	30	4.7	12.0	24.5	------	------	------	------	------	------
		60	7.4	16.0	28.5	------	------	------	------	------	------
		90	11.0	20.0	32.0	------	------	------	------	------	------
	C	30	2.5	5.4	11.2	22.0	35.0	65.0	104	213	341
		60	3.6	7.7	15.5	27.0	40.5	70.0	109	216	344
		90	5.3	11.2	20.5	31.5	45.0	75.0	113	220	348
4	A and B	30	3.1	6.6	13.0	22.0	34.5	64.0	99	189	309
		60	4.7	9.8	17.5	27.5	40.0	69.0	104	193	314
		90	7.4	14.0	22.0	32.5	44.0	73.0	108	197	318
	C	30	2.2	3.7	6.3	11.1	18.0	41.0	71	147	245
		60	2.8	5.1	9.2	15.5	24.0	47.5	77	152	250
		90	4.0	7.2	12.5	20.5	29.5	53.0	82	158	256

TABLE 40

Sags for Siemens-Martin Steel Wire

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the sags being such that when loaded at 0°F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Steel Wire Gage No.	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
6	C	30	13.5	35.5	67.0	147	251	379	528	------
		60	18.5	42.5	73.0	152	256	384	533	------
		90	23.5	48.5	79.0	158	261	389	538	------
4	A and B	30	15.0	37.0	65.0	136	231	357	487	------
		60	20.5	43.5	72.0	143	237	362	492	------
		90	26.0	50.0	78.0	148	242	367	498	------
	C	30	8.2	17.5	36.0	94	172	268	382	815
		60	10.6	22.5	43.0	102	179	276	388	822
		90	14.0	29.0	51.0	110	188	282	395	830

TABLE 41

Sags for High-Tension Steel Wire

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the sags being such that when loaded at 0°F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Steel Wire Gage No.	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
6	C	30	3.6	6.0	9.7	25.0	66.0	130	218	595
		60	4.0	6.8	11.2	30.0	75.0	143	231	602
		90	4.3	7.5	12.5	34.5	87.0	154	244	610
4	A and B	30	4.1	7.2	11.5	29.5	71.0	135	215	537
		60	4.7	8.2	13.5	34.5	82.0	147	225	547
		90	5.3	9.3	16.0	42.0	92.0	159	237	556
	C	30	3.4	5.2	7.9	16.5	34.0	68	126	394
		60	3.7	5.8	8.8	19.0	39.5	79	140	405
		90	4.1	6.4	9.7	21.5	45.5	89	154	419

TABLE 42

Sags for Ordinary Grade Steel Cable

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the sags being such that when loaded at 0°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Cable diameter (inches)	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
¼	A and B	30	3.8	8.9	19.0	32.5	48.0	86.0	131	250	406
		60	5.4	12.5	23.0	36.5	52.0	90.0	135	254	409
		90	7.8	16.0	27.0	40.5	56.0	93.0	138	257	413
	C	30	2.3	4.5	8.5	16.0	28.0	58.0	97.0	195	323
		60	2.0	5.9	11.4	20.5	33.0	63.0	102	200	328
		90	3.8	7.8	15.0	25.0	38.0	68.0	106	205	332
5/16	A and B	30	2.6	4.8	7.9	13.0	20.5	43.0	72.0	147	241
		60	3.6	6.3	10.8	17.0	25.5	48.5	78.0	151	247
		90	4.7	8.4	14.0	21.0	31.0	54.0	83.0	157	252
	C	30	1.9	3.3	5.2	7.8	11.5	24.0	44.0	105	185
		60	2.3	4.1	6.3	9.9	14.5	29.0	51.0	112	191
		90	2.9	5.2	8.1	12.5	18.0	35.0	58.0	118	199
⅜	A and B	30	2.4	4.2	6.7	10.1	14.5	29.0	49.5	107	183
		60	3.1	5.4	8.6	13.0	18.5	35.0	56.0	114	190
		90	4.3	7.0	11.2	16.5	23.0	40.5	63.0	121	197
	C	30	1.9	3.1	4.7	6.7	9.6	17.5	30.0	73.0	134
		60	2.3	3.7	5.6	8.2	11.8	21.5	36.0	81.0	142
		90	2.8	4.6	7.0	10.3	14.5	26.5	42.0	89.0	151
7/16	A and B	30	2.3	3.9	5.8	8.4	11.5	21.0	34.0	75.0	131
		60	2.9	5.0	7.4	10.7	14.5	25.5	40.5	83.0	139
		90	3.8	6.3	9.7	13.5	18.5	31.0	47.5	91.0	148
	C	30	1.9	3.0	4.3	6.3	8.6	14.5	22.5	50.0	92
		60	2.2	3.5	5.2	7.4	10.1	17.0	27.0	57.0	102
		90	2.6	4.4	6.5	9.0	12.0	21.0	32.5	66.0	112
½	A and B	30	2.3	3.7	5.6	8.0	11.0	19.0	30.0	66.0	116
		60	2.9	4.8	7.0	10.1	13.5	23.5	36.5	74.0	125
		90	3.8	6.1	9.2	13.0	17.5	28.5	43.0	83.0	135
	C	30	1.9	3.0	4.3	6.1	8.2	13.5	21.0	44.0	80
		60	2.2	3.5	5.2	7.1	9.8	16.0	25.0	51.0	91
		90	2.5	4.2	6.3	8.8	12.0	19.5	30.0	59.0	100
9/16	A and B	30	2.3	3.6	5.4	7.6	10.3	17.0	26.5	54.0	94
		60	2.8	4.7	6.7	9.5	12.5	21.0	31.5	62.0	104
		90	3.7	6.0	8.6	12.0	16.0	26.0	37.5	70.0	113
	C	30	1.9	3.0	4.3	5.9	7.7	12.5	19.5	38.5	66
		60	2.2	3.5	5.0	6.9	9.4	15.0	23.0	44.5	75
		90	2.6	4.2	6.1	8.4	11.0	18.5	27.5	51.0	85
⅝	A and B	30	2.2	3.6	5.4	7.6	10.1	16.0	25.0	49.0	85
		60	2.8	4.5	6.5	9.3	12.0	20.0	29.5	57.0	94
		90	3.7	5.8	8.6	11.8	15.5	24.5	35.5	65.0	103
	C	30	1.9	3.0	4.3	5.9	7.7	12.5	18.5	35.5	61
		60	2.2	3.4	4.9	6.7	9.1	14.5	22.0	41.5	69
		90	2.5	4.2	6.1	8.4	11.0	17.5	26.0	48.0	78

TABLE 43

Sags for Siemens-Martin Steel Cable

HEAVY LOADING DISTRICT

(At 30, 60, and 90°F. without load, the sags being such that when loaded at 0°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Cable diameter (inches)	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
	A and B	30	10.3	20.5	39.5	96.0	166.0	270	381	792
		60	12.5	25.0	46.0	103.0	176 0	280	389	799
		90	16.0	31.0	53.0	110.0	188.0	287	396	806
5/16		30	7.0	12.5	22.0	57.0	119.0	197	289	664
	C	60	8.2	15.5	26.0	66.0	127.0	205	297	672
		90	9.6	18.5	31.5	74.0	137.0	213	306	680
		30	8.9	15.5	26.5	64.0	123.0	198	288	640
	A and B	60	10 6	19.0	32.0	72.0	131 0	208	295	649
		90	12.5	23.5	38.0	80.0	140.0	216	302	657
		30	6.5	10.8	17.5	39.5	77.0	137	208	499
3/8	C	60	7.5	12.5	20.0	45.5	87.0	144	218	509
		90	8.6	14.5	24.0	52.0	96.0	155	229	520
		30	7.9	13.0	21.0	45.0	84.0	140	203	479
	A and B	60	9.4	15.5	24.5	51.0	93.0	150	214	487
		90	11.3	19.0	29.5	59.0	103.0	159	224	495
		30	6.0	9.9	15.0	30.0	55.0	93	144	358
7/16	C	60	6.9	11.4	17.5	35.0	63.0	104	154	370
		90	7.9	13.0	20.0	40.5	71.0	115	167	383
		30	7.4	12.5	20.0	41.0	73.0	121	179	414
	A and B	60	9.1	15.5	23.5	47.0	83.0	131	190	426
		90	11.0	18.0	27.5	55.0	92.0	142	201	438
		30	6.2	9.9	15.0	29.0	50.0	82	123	312
1/2	C	60	7.0	11.3	17.0	33.0	57.0	92	136	326
		90	7.9	12.5	19.0	37.5	65.0	102	148	340
		30	7.4	12.0	18.0	35.0	61.0	98	145	337
	A and B	60	9.0	14.0	21.0	41.0	69.0	109	158	350
		90	10.6	17.0	25.0	47.5	79.0	119	170	364
		30	6.0	9.5	14.0	25.5	44.0	69	103	253
9/16	C	60	6.8	10.9	16.0	30.0	51.0	78	113	269
		90	7.7	12.5	18.0	34.0	57.0	87	125	285
		30	7.2	11.8	17.5	33.5	57.0	88	130	301
	A and B	60	8.7	14.0	20.5	39.5	64.0	98	140	315
		90	10.3	16.0	24.0	45.0	73.0	109	153	330
		30	5.8	9.4	13.5	25.5	42.0	64	93	227
5/8	C	60	6.6	10.8	15.5	29.0	47.5	71	104	241
		90	7.4	12.0	17.5	32.5	53.0	81	115	260

TABLE 44

Sags for High-Tension Steel Cable

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the sags being such that when loaded at 0°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Cable diameter (inches)	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
	A and B	30	4.3	6.9	10.4	22.0	43.0	78.0	134	391
		60	4.8	7.6	11.7	24.0	47.5	88.0	147	405
		90	5.3	8.4	13.0	27.0	54.0	97.0	159	418
5/16		30	3.1	4.8	7.2	15.0	26.5	45.5	74.0	252
	C	60	3.4	5.4	7.9	16.5	30.0	50.0	82.0	270
		90	3.8	6.0	8.6	17.5	33.5	56.0	90.0	284
		30	4.1	6.3	9.4	19.0	33.5	56.0	89.0	271
	A and B	60	4.5	7.2	10.8	21.0	37.0	62.0	99.0	286
		90	5.0	8.1	12.0	24.0	42.0	69.0	110.0	301
3/8		30	3.1	5.4	7.6	14.5	23.5	37.0	57.0	162
	C	60	3.4	5.7	8.3	15.5	25.0	40.5	63.0	171
		90	3.8	6.3	8.9	16.5	28.0	44.5	70.0	180
		30	4.0	6.3	9.0	17.5	29.0	44.5	67.0	181
	A and B	60	4.4	7.0	10.2	19.5	32.5	49.5	74.0	196
		90	4.8	7.8	11.4	21.5	35.5	55.0	81.0	211
7/16		30	3.1	4.8	7.0	13.5	22.0	33.5	48.0	118
	C	60	3.3	5.2	7.5	14.5	23.5	36.0	51.0	127
		90	3.6	5.7	8.3	15.5	26.0	38.0	55.0	137
		30	3.8	5.7	8.3	16.5	27.5	42.5	62.0	160
	A and B	60	4.3	6.6	9.7	18.0	30.5	47.5	69.0	173
		90	4.8	7.5	11.2	20.0	33.5	53.0	76.0	187
1/2		30	3.1	5.0	7.2	13.5	21.5	32.5	45.5	109
	C	60	3.4	5.4	7.6	14.5	23.0	34.5	49.0	118
		90	3.6	5.7	8.2	15.5	24.0	36.5	52.0	126
		30	3.8	5.7	8.3	15.5	26.5	39.5	57.0	134
	A and B	60	4.3	6.6	9.4	18.0	29.5	44.0	62.0	146
		90	4.8	7.5	10.8	20.0	32.5	48.0	69.0	158
9/16		30	3.1	4.9	7.2	13.5	21.0	31.0	44.0	97
	C	60	3.4	5.4	7.7	14.5	22.0	33.0	46.0	106
		90	3.6	5.7	8.3	15.5	24.0	36.0	50.0	113
		30	3.8	5.8	8.3	15.5	25.0	37.5	54.0	124
	A and B	60	4.3	6.6	9.4	17.5	28.0	42.0	60.0	134
		90	4.8	7.5	10.4	19.5	31.0	46.0	66.0	146
5/8		30	3.1	4.9	7.2	13.0	21.0	30.5	43.0	90
	C	60	3.4	5.4	7.9	14.0	22.5	33.0	45.5	96
		90	3.6	5.8	8.6	15.0	24.0	35.0	48.0	106

TABLE 45

Sags for Bare Copper-Covered Steel Wire (Ordinary Grade)

HEAVY LOADING DISTRICT

(The sags being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength.)

Size A. W. G. No.	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
6	A and B	30	1.7	3.2	5.9	10.9	------	------	------	------	------
		60	2.0	3.8	7.2	13.7	------	------	------	------	------
		90	2.3	4.9	9 4	17.3	------	------	------	------	------
4	A and B	30	1.7	2.9	4.6	7.0	10.8	27.4	57.4	------	------
		60	1.9	3.4	5.4	8.6	13.7	34.6	64.2	------	------
		90	2.3	4.0	6.6	10.8	17.4	39.6	70.7	------	------

TABLE 46

Sags for Bare Copper-Covered Steel Cable

HEAVY LOADING DISTRICT

(The sags being such that when loaded at 0°F. the cable will be stressed to 50 per cent of its ultimate strength.)

Diameter (inch)	Grade of Construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	800	1,000
		F.								
5/16	A and B	30	5.6	9.3	15.0	34.6	73.8	------	------	------
		60	6.2	10.4	17.1	39.9	83.4	------	------	------
		90	7.0	11.9	19.7	45.6	93.4	------	------	------
3/8	A and B	30	5.6	9.1	13.7	27.4	49.9	85.6	202	------
		60	6.1	10.1	15.2	30.6	56.2	95.2	215	------
		90	6.9	11.4	17.3	34.8	63.5	106.0	228	------
7/16	A and B	30	5.7	9.2	13.8	26.6	46.8	77.0	172	316
		60	6.4	10.2	15.3	29.8	52.3	85.6	186	331
		90	7.2	11.5	17.2	33.6	58.8	95.0	200	345
1/2	A and B	30	5.7	9.1	13.4	25.2	42.7	67.0	146	265
		60	6.2	10.0	14.8	28.0	47.3	74.2	157	280
		90	7.0	11.1	16.5	31.2	52.8	82.2	171	295
9/16	A and B	30	5.8	9.1	13.4	25.1	41.3	63.7	131	234
		60	6.4	10.1	14.8	27.5	45.5	69.8	142	248
		90	7.1	11.2	16.5	31.1	50.4	77.0	154	262

TABLE 47

Sags for Bare Stranded Aluminum

HEAVY LOADING DISTRICT

(Sags being such that when loaded at 0°F. the conductor will be stressed to 50 per cent of its ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	(Sags (in inches) for span lengths (in feet) of—								
			100	125	150	200	250	300	400	500	600
		°F.									
1	A and B	30	12.5	24.6	42.1	------	------	------	------	------	------
		60	18.2	30.3	47.2	------	------	------	------	------	------
		90	23.0	35.1	51.8	------	------	------	------	------	------
	C	30	4.3	12.3	26.6	------	------	------	------	------	------
		60	9.4	20.1	33.5	------	------	------	------	------	------
		90	16.1	26.4	39.6	------	------	------	------	------	------
0	A and B	30	7.4	16.2	31.0	63.4	109.0	170.0	294	------	------
		60	13.0	24.6	37.1	69.6	115.0	177.0	304	------	------
		90	19.7	30.0	44.6	75.4	120.0	182.0	310	------	------
	C	30	2.9	7.2	15.5	45.1	81.0	127.0	239	------	------
		60	6.2	14.1	25.2	53.3	88.8	133.0	246	------	------
		90	12.7	21.6	32.4	60.0	95.4	140.0	251	------	------
00	A and B	30	5.0	10.8	22.0	49.4	85.2	127.0	241	------	------
		60	10.8	18.6	29.5	56.6	91.2	133.0	247	------	------
		90	16.8	25.2	36.0	63.4	97.2	140.0	254	------	------
	C	30	2.6	5.1	9.7	29.7	60.6	96.5	189	------	462
		60	5.0	9.9	18.0	39.4	70.2	106.0	198	------	472
		90	10.8	17.4	26.3	48.0	78.0	114.0	207	------	479
000	A and B	30	3.8	7.5	14.0	37.4	73.2	102.0	197	------	469
		60	7.7	14.7	23.4	46.5	75.6	111.0	205	------	478
		90	14.6	21.9	31.0	54.2	84.0	119.0	213	------	487
	C	30	2.2	4.2	6.8	20.6	45.0	74.2	151	------	376
		60	3.8	7.5	13.3	31.2	56.4	92.2	161	------	387
		90	8.4	15.0	21.6	41.3	65.4	95.0	172	------	396
0000	A and B	30	3.1	6.0	10.4	29.3	53.4	83.5	165	------	395
		60	6.5	12.0	19.1	39.4	62.4	92.9	175	------	403
		90	13.2	19.5	27.0	48.0	74.4	102.0	183	------	413
	C	30	2.2	3.6	6.1	14.9	31.8	57.6	125	------	312
		60	3.6	6.3	10.4	24.9	43.8	70.5	137	------	324
		90	7.9	12.0	19.1	35.0	55.2	81.4	148	------	335

TABLE 48

Sags for Bare Stranded Aluminum, Steel Reinforced

HEAVY LOADING DISTRICT

(Sags being such that when loaded at 0°F. the cable will be stressed to 50 per cent of its ultimate strength for grades A and B, and 60 per cent for grade C.)

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	150	200	300	400	500	600	700	800
		°F.									
4	A and B	32	5.4	9.0	30.2	110.6	------	------	------	------	------
		60	6.6	10.8	34.2	114.0	------	------	------	------	------
		120	9.0	16.8	40.2	121.2	------	------	------	------	------
	C	32	5.4	8.8	11.8	59.0	------	------	------	------	------
		60	6.6	10.6	14.4	64.2	------	------	------	------	------
		120	9.0	15.6	22.2	74.4	------	------	------	------	------
2	A and B	32	5.4	9.0	12.6	58.4	138.0	------	------	------	------
		60	6.6	10.8	15.6	67.2	143.0	------	------	------	------
		120	9.0	16.8	25.0	76.2	153.2	------	------	------	------
	C	32	5.4	8.8	11.8	24.0	81.0	------	------	------	------
		60	6.6	10.6	14.4	31.4	87.0	------	------	------	------
		120	9.0	15.6	22.2	40.6	97.2	------	------	------	------
1	A and B	32	5.4	9.0	12.6	39.6	103.2	187.4	------	------	------
		60	6.6	10.8	15.6	48.2	110.4	190.8	------	------	------
		120	9.0	16.8	25.0	52.8	121.2	204.6	------	------	------
	C	32	5.4	8.8	11.8	18.2	50.4	111.0	------	------	------
		60	6.6	10.6	14.4	22.2	58.8	118.2	------	------	------
		120	9.0	15.6	22.2	35.8	68.6	130.8	------	------	------
0	A and B	32	5.4	9.0	12.6	24.6	73.8	144.0	------	------	------
		60	6.6	10.8	15.6	32.6	83.0	150.6	------	------	------
		120	9.0	16.8	25.0	44.6	94.8	164.4	------	------	------
	C	32	5.4	8.8	11.8	18.2	35.0	85.8	154.2	------	------
		60	6.6	10.6	14.4	22.2	44.8	96.6	163.0	------	------
		120	9.0	15.6	22.2	35.8	58.8	109.2	177.6	------	------
00	A and B	32	5.4	9.0	12.6	19.8	50.6	110.1	183.6	------	------
		60	6.6	10.8	15.6	24.6	63.6	123.6	197.0	------	------
		120	9.0	16.8	25.0	40.6	81.2	140.6	211.2	------	------
	C	32	5.4	8.8	11.8	18.2	26.4	57.6	110.4	------	------
		60	6.6	10.6	14.4	22.2	33.4	71.8	128.4	------	------
		120	9.0	15.6	22.2	35.8	50.6	89.8	145.2	------	------
000	A and B	32	5.4	9.0	12.6	19.8	40.2	85.4	147.0	------	------
		60	6.6	10.8	15.6	24.6	51.8	99.8	162.0	------	------
		120	9.0	16.8	25.0	40.6	72.0	121.2	181.4	------	------
	C	32	5.4	8.8	11.8	18.2	25.0	46.8	88.2	147.6	------
		60	6.6	10.6	14.4	22.2	30.2	58.8	104.4	164.4	------
		120	9.0	15.6	22.2	35.8	49.4	81.0	126.6	185.4	------
0000	A and B	32	5.4	9.0	12.6	19.8	33.4	66.6	117.0	180.0	------
		60	6.6	10.8	15.6	24.6	42.6	81.6	134.4	197.4	------
		120	9.0	16.8	25.0	40.6	64.2	105.2	157.0	220.6	------
	C	32	5.4	8.8	11.8	18.2	25.0	38.4	69.6	109.8	172.2
		60	6.6	10.6	14.4	22.2	30.2	47.4	81.8	130.2	189.0
		120	9.0	15.6	22.2	35.8	49.4	73.2	111.0	159.0	217.8

Note. The values in this table were supplied by the Aluminum Company of America.

TABLE 49

Stringing Tensions for Medium and Hard-Drawn Bare Solid Copper Wire

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Tension (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	168	76	46	------	------	------	------	------	------
		60	116	57	41	------	------	------	------	------	------
		90	77	48	38	------	------	------	------	------	------
6	A and B	30	268	152	97	------	------	------	------	------	------
		60	185	111	82	------	------	------	------	------	------
		90	124	87	72	------	------	------	------	------	------
	C	30	478	367	251	161	------	------	------	------	------
		60	385	277	183	128	------	------	------	------	------
		90	297	196	137	105	------	------	------	------	------
4	A and B	30	640	525	401	297	228	179	156	------	------
		60	496	391	293	233	192	163	148	------	------
		90	355	274	215	184	166	146	140	------	------
	C	30	891	823	721	614	502	320	240	------	------
		60	748	676	581	483	387	264	218	------	------
		90	597	535	447	359	300	228	197	------	------
2	A and B	30	1,104	1,023	911	791	678	496	412	339	313
		60	875	788	700	590	522	417	365	323	305
		90	639	577	511	449	409	349	331	311	295
	C	30	1,448	1,377	1,305	1,226	1,122	896	700	496	417
		60	1,216	1,143	1,080	997	903	723	584	454	397
		90	976	913	851	794	705	572	491	418	378
1	A and B	30	1,379	1,304	1,205	1,113	988	780	636	518	472
		60	1,080	1,008	944	852	754	622	544	481	455
		90	803	753	688	642	590	518	484	452	432
	C	30	1,788	1,742	1,676	1,575	1,500	1,277	1,080	780	645
		60	1,486	1,435	1,386	1,290	1,228	1,035	878	684	602
		90	1,191	1,149	1,100	1,021	970	812	731	615	563
0	A and B	30	1,732	1,657	1,566	1,471	1,350	1,143	954	771	692
		60	1,375	1,276	1,214	1,131	1,058	900	812	700	655
		90	1,007	954	896	854	808	750	692	646	622
	C	30	2,221	2,171	2,080	1,994	1,919	1,740	1,521	1,168	979
		60	1,848	1,795	1,699	1,645	1,566	1,409	1,243	1,011	892
		90	1,476	1,434	1,351	1,302	1,247	1,135	1,018	892	825
00	A and B	30	2,128	2,055	1,982	1,878	1,763	1,538	1,366	1,116	1,001
		60	1,654	1,596	1,549	1,456	1,382	1,236	1,142	996	934
		90	1,215	1,178	1,142	1,095	1,058	1,001	960	908	882
	C	30	2,731	2,670	2,608	2,513	2,430	2,231	2,042	1,669	1,434
		60	2,243	2,198	2,145	2,066	1,967	1,827	1,696	1,420	1,289
		90	1,796	1,743	1,696	1,639	1,587	1,456	1,383	1,242	1,170
0000	A and B	30	3,171	3,107	3,080	2,948	2,890	2,658	2,432	2,168	1,985
		60	2,426	2,392	2,342	2,292	2,250	2,083	2,010	1,885	1,810
		90	1,735	1,718	1,718	1,726	1,735	1,694	1,676	1,694	1,676
	C	30	4,001	3,960	3,928	3,850	3,792	3,593	3,430	3,053	2,721
		60	3,270	3,238	3,188	3,129	3,070	2,948	2,831	2,581	2,390
		90	2,521	2,514	2,508	2,456	2,456	2,322	2,307	2,215	2,140

TABLE 50

Stringing Tensions for Medium and Hard-Drawn Bare Stranded Copper Wire

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	650	538	400	230	176	------	------	------	------
		60	506	403	294	195	160	------	------	------	------
		90	368	288	218	170	147	------	------	------	------
	C	30	909	835	730	506	323	------	------	------	------
		60	765	692	589	390	269	------	------	------	------
		90	621	550	454	301	228	------	------	------	------
2	A and B	30	1,149	1,061	941	712	525	374	322	------	------
		60	915	832	728	546	432	343	312	------	------
		90	692	619	536	426	374	322	302	------	------
	C	30	1,508	1,449	1,368	1,175	957	604	432	------	------
		60	1,274	1,206	1,139	957	764	520	411	------	------
		90	1,040	978	910	759	614	458	399	------	------
1	A and B	30	1,439	1,360	1,195	1,030	772	574	482	449	------
		60	1,142	1,069	983	785	653	515	462	442	------
		90	858	799	726	614	541	475	442	429	------
	C	30	1,960	1,892	1,729	1,551	1,340	917	673	574	535
		60	1,564	1,505	1,432	1,267	1,010	779	627	554	528
		90	1,267	1,208	1,148	1,010	865	673	587	541	521
0	A and B	30	1,884	1,801	1,710	1,519	1,278	938	764	681	647
		60	1,511	1,436	1,353	1,204	1,013	805	714	664	639
		90	1,145	1,087	1,013	921	822	722	681	647	631
	C	30	2,407	2,349	2,274	2,117	1,926	1,519	1,096	896	805
		60	2,034	1,975	1,909	1,760	1,486	1,262	988	863	789
		90	1,660	1,610	1,544	1,419	1,287	1,013	905	830	772
00	A and B	30	2,352	2,258	2,195	1,985	1,775	1,386	1,124	998	935
		60	1,869	1,806	1,733	1,565	1,418	1,187	1,008	966	924
		90	1,418	1,365	1,323	1,197	1,145	1,019	966	935	914
	C	30	2,972	2,908	2,867	2,772	2,531	2,111	1,628	1,323	1,176
		60	2,489	2,436	2,394	2,300	2,100	1,743	1,449	1,250	1,145
		90	2,016	1,974	1,932	1,869	1,701	1,460	1,302	1,176	1,113
0000	A and B	30	3,752	3,685	3,602	3,420	3,220	2,805	2,407	2,125	1,942
		60	2,988	2,955	2,888	2,756	2,590	2,341	2,158	1,975	1,892
		90	2,258	2,241	2,224	2,141	2,058	1,992	1,942	1,876	1,859
	C	30	4,665	4,631	4,598	4,465	4,233	3,868	3,503	2,988	2,490
		60	3,918	3,884	3,851	3,735	3,552	3,270	2,905	2,722	2,374
		90	3,171	3,137	3,104	3,038	2,888	2,706	2,556	2,523	2,291

TABLE 51

Stringing Tensions for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	C	30	114	63	50				
		60	86	57	47				
		90	66	50	44				
6	A and B	30	194	116	101				
		60	138	100	85				
		90	107	89	79				
	C	30	408	272	169	132			
		60	315	209	138	115			
		90	240	158	119	107			
4	A and B	30	554	411	301	225	195		
		60	414	310	238	197	178		
		90	301	231	195	174	168		
	C	30	840	738	602	476	362		
		60	692	592	481	375	300		
		90	551	465	365	297	251		
2	A and B	30	1,044	932	786	660	559	443	386
		60	810	716	592	517	459	402	355
		90	608	538	467	420	391	363	334
	C	30	1,391	1,318	1,198	1,093	978	739	590
		60	1,160	1,083	976	870	783	618	522
		90	928	875	776	694	629	522	470
1	A and B	30	1,327	1,217	1,090	964	845	678	586
		60	1,038	953	845	744	682	573	527
		90	773	694	642	600	557	511	485
	C	30	1,749	1,660	1,562	1,454	1,356	1,097	917
		60	1,454	1,363	1,294	1,198	1,087	888	780
		90	1,160	1,090	1,022	930	882	753	685
0	A and B	30	1,686	1,566	1,488	1,322	1,201	996	871
		60	1,325	1,230	1,148	1,053	974	858	767
		90	979	900	880	812	783	730	704
	C	30	2,180	2,098	1,990	1,920	1,807	1,575	1,334
		60	1,804	1,729	1,645	1,562	1,496	1,272	1,135
		90	1,438	1,372	1,293	1,256	1,185	1,077	978
00	A and B	30	2,108	1,977	1,883	1,754	1,657	1,404	1,252
		60	1,643	1,549	1,481	1,372	1,288	1,190	1,095
		90	1,221	1,132	1,116	1,064	1,064	1,001	970
	C	30	2,709	2,609	2,490	2,425	2,295	2,081	1,872
		60	2,228	2,139	2,060	1,977	1,899	1,727	1,550
		90	1,774	1,706	1,617	1,586	1,492	1,403	1,335
0000	A and B	30	3,130	3,021	2,957	2,858	2,715	2,508	2,309
		60	2,408	2,340	2,290	2,216	2,190	2,073	1,950
		90	1,751	1,717	1,735	1,735	1,726	1,701	1,710
	C	30	3,969	3,918	3,842	3,751	3,679	3,461	3,252
		60	3,238	3,187	3,120	3,052	3,029	2,847	2,680
		90	2,513	2,498	2,463	2,422	2,407	2,331	2,290

TABLE 52

Stringing Tensions for T. B. W. P. Solid Soft Copper Wire

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—				
			100	125	150	175	200
		F.					
6	C	30	58	54	49		
		60	54	51	49		
		90	49	47	48		
4	A and B	30	109	98	91		
		60	96	90	88		
		90	88	85	81		
	C	30	171	137	121		
		60	138	121	112		
		90	116	109	103		
2	A and B	30	324	269	235	224	219
		60	248	224	209	209	206
		90	201	198	193	196	196
	C	30	543	433	349	308	287
		60	391	329	290	274	261
		90	276	266	253	248	248
1	A and B	30	491	416	367	334	324
		60	360	328	318	301	295
		90	278	282	285	278	275
	C	30	810	682	576	485	442
		60	580	507	449	416	393
		90	406	383	376	354	350
0	A and B	30	783	663	588	534	506
		60	551	497	485	456	456
		90	414	414	414	414	431
	C	30	1,156	1,024	892	787	713
		60	824	746	680	630	605
		90	592	568	551	538	526
00	A and B	30	1,080	991	898	798	757
		60	772	731	699	673	662
		90	548	574	584	579	584
	C	30	1,539	1,424	1,304	1,190	1,085
		60	1,120	1,043	976	944	887
		90	782	772	778	761	757
0000	A and B	30	2,001	1,876	1,768	1,634	1,618
		60	1,410	1,353	1,360	1,319	1,303
		90	1,020	1,020	1,062	1,070	1,136
	C	30	2,622	2,522	2,422	2,273	2,233
		60	1,942	1,868	1,817	1,776	1,726
		90	1,335	1,353	1,410	1,394	1,435

TABLE 53

Stringing Tensions for Ordinary Grade Steel Wire

HEAVY LOADING DISTRICT

(At 30, 60, and 90°F. without load, the tensions being such that when loaded at 0°F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Steel wire gage No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	260	130	89	------	------	------	------	------	------
		60	165	99	79	------	------	------	------	------	------
		90	110	83	70	------	------	------	------	------	------
6	A and B	30	320	190	135	------	------	------	------	------	------
		60	200	140	120	------	------	------	------	------	------
		90	135	115	105	------	------	------	------	------	------
	C	30	580	450	300	210	170	140	125	115	110
		60	430	300	220	170	150	130	120	110	110
		90	280	210	160	145	130	125	115	110	110
4	A and B	30	640	480	360	280	240	200	185	175	165
		60	430	330	260	230	210	185	180	170	165
		90	270	230	210	195	185	175	170	165	165
	C	30	970	850	710	560	450	310	260	220	210
		60	740	630	510	410	340	270	240	220	210
		90	530	440	360	310	280	240	220	210	200

TABLE 54

Stringing Tensions for Siemens-Martin Steel Wire

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the tensions being such that when loaded at 0°F., the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C.)

Steel wire gage No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of							
			200	250	300	400	500	600	700	1,000
		°F.								
6	C	30	440	260	200	160	150	145	140	------
		60	330	220	185	155	150	145	140	------
		90	250	190	170	150	145	140	140	------
4	A and B	30	530	350	280	240	220	210	210	------
		60	400	290	260	230	220	210	210	------
		90	310	260	240	220	210	210	200	------
	C	30	1,000	730	520	340	300	270	270	260
		60	780	570	420	320	290	270	260	260
		90	590	440	360	300	280	260	260	260

TABLE 55

Stringing Tensions for High-Tension Steel Wire

HEAVY LOADING DISTRICT

(At 30, 60, and 90°F. without load, the tensions being such that when loaded at 0°F., the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C.)

Steel wire gage No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
6	C	30	1,730	1,590	1,420	960	560	400	330	250
		60	1,570	1,430	1,260	810	480	380	320	250
		90	1,400	1,260	1,100	680	420	350	300	250
4	A and B	30	1,970	1,800	1,590	1,110	710	540	470	390
		60	1,730	1,570	1,370	930	620	500	440	380
		90	1,500	1,340	1,160	770	550	460	420	370
	C	30	2,560	2,430	2,280	1,940	1,500	1,070	790	520
		60	2,330	2,190	2,050	1,720	1,290	930	710	500
		90	2,100	1,960	1,820	1,500	1,110	820	650	490

TABLE 56

Stringing Tensions for Ordinary Grade Steel Cable

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the tensions being such that when loaded at 0°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.)

Cable diameter (inches)	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
¼	A and B	30	470	320	220	170	150	130	125	120	115
		60	340	230	175	150	140	125	125	115	115
		90	230	175	150	135	130	120	120	115	115
	C	30	770	630	480	350	260	195	170	150	145
		60	610	500	370	270	220	180	160	150	140
		90	470	360	270	220	190	165	155	145	135
5/16	A and B	30	1,140	1,010	880	740	610	450	390	340	330
		60	900	780	670	560	490	400	360	330	320
		90	670	580	500	450	410	360	340	320	320
	C	30	1,550	1,440	1,330	1,210	1,090	820	620	480	420
		60	1,290	1,190	1,100	990	880	680	550	450	410
		90	1,040	960	870	780	690	550	480	420	390
⅜	A and B	30	1,680	1,580	1,460	1,320	1,180	920	780	640	580
		60	1,350	1,260	1,150	1,040	930	770	690	600	560
		90	1,020	950	870	800	740	660	620	560	540
	C	30	2,200	2,130	2,030	1,920	1,800	1,530	1,280	940	800
		60	1,850	1,780	1,690	1,590	1,480	1,260	1,070	840	760
		90	1,510	1,460	1,370	1,280	1,170	1,020	910	770	710
7/16	A and B	30	2,570	2,480	2,370	2,260	2,140	1,870	1,630	1,320	1,180
		60	2,080	2,000	1,900	1,810	1,710	1,530	1,370	1,180	1,110
		90	1,600	1,540	1,480	1,420	1,360	1,250	1,170	1,080	1,050
	C	30	3,280	3,210	3,130	3,040	2,940	2,700	2,450	1,990	1,690
		60	2,780	2,710	2,640	2,560	2,470	2,250	2,060	1,730	1,520
		90	2,280	2,220	2,160	2,100	2,020	1,860	1,720	1,510	1,390
½	A and B	30	3,120	3,020	2,930	2,830	2,720	2,470	2,200	1,790	1,600
		60	2,520	2,460	2,380	2,290	2,180	1,980	1,840	1,590	1,480
		90	1,940	1,910	1,860	1,800	1,730	1,630	1,550	1,420	1,380
	C	30	3,970	3,900	3,830	3,740	3,640	3,420	3,180	2,720	2,320
		60	3,380	3,300	3,230	3,150	3,070	2,880	2,670	2,330	2,060
		90	2,780	2,720	2,660	2,590	2,520	2,380	2,240	2,030	1,860
9/16	A and B	30	4,210	4,150	4,070	3,960	3,840	3,600	3,380	2,930	2,620
		60	3,440	3,380	3,300	3,230	3,150	2,960	2,800	2,560	2,380
		90	2,670	2,630	2,580	2,530	2,480	2,410	2,350	2,260	2,180
	C	30	5,310	5,280	5,230	5,140	5,050	4,840	4,590	4,140	3,720
		60	4,500	4,470	4,420	4,350	4,280	4,100	3,900	3,560	3,290
		90	3,700	3,680	3,650	3,600	3,540	3,400	3,270	3,080	2,920
⅝	A and B	30	5,250	5,160	5,070	4,980	4,880	4,660	4,390	3,960	3,590
		60	4,280	4,190	4,140	4,060	3,990	3,830	3,680	3,440	3,240
		90	3,340	3,290	3,250	3,220	3,180	3,140	3,080	2,980	2,930
	C	30	6,550	6,500	6,440	6,370	6,280	6,100	5,860	5,410	4,970
		60	5,570	5,530	5,480	5,410	5,340	5,190	4,980	4,660	4,380
		90	4,560	4,540	4,500	4,470	4,430	4,310	4,210	4,030	3,880

TABLE 57

Stringing Tensions for Siemens-Martin Steel Cable

HEAVY LOADING DISTRICT

(At 30, 60, and 90 °F. without load, the tensions being such that when loaded at 0°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C.)

Cable diameter (inches)	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
	A and B	30	1,210	930	720	520	450	420	410	410
		60	990	770	620	480	440	410	400	400
		90	780	620	530	450	430	400	390	390
5/16	C	30	1,790	1,520	1,270	870	650	570	530	480
		60	1,530	1,290	1,080	760	610	550	520	470
		90	1,300	1,070	980	680	570	520	500	460
	A and B	30	1,940	1,700	1,450	1,070	870	770	730	680
		60	1,620	1,420	1,210	950	820	740	720	670
		90	1,310	1,150	1,020	860	770	710	700	660
3/8	C	30	2,690	2,480	2,250	1,750	1,360	1,110	1,010	870
		60	2,360	2,140	1,920	1,520	1,230	1,040	960	850
		90	2,030	1,830	1,630	1,310	1,100	970	910	830
	A and B	30	3,140	2,910	2,660	2,220	1,840	1,600	1,470	1,340
		60	2,650	2,440	2,250	1,910	1,660	1,490	1,420	1,300
		90	2,190	2,050	1,890	1,650	1,500	1,400	1,350	1,270
7/16	C	30	4,090	3,920	3,740	3,260	2,790	2,400	2,120	1,730
		60	3,600	3,440	3,270	2,860	2,460	2,160	1,980	1,670
		90	3,110	2,960	2,810	2,470	2,160	1,950	1,830	1,610
	A and B	30	3,910	3,660	3,390	2,930	2,540	2,240	2,040	1,790
		60	3,340	3,120	2,900	2,550	2,250	2,040	1,910	1,740
		90	2,780	2,580	2,410	2,180	2,020	1,900	1,810	1,690
1/2	C	30	4,950	4,800	4,600	4,150	3,660	3,260	2,890	2,370
		60	4,360	4,220	4,040	3,650	3,250	2,930	2,660	2,280
		90	3,770	3,650	3,500	3,160	2,840	2,620	2,440	2,180
	A and B	30	5,320	5,120	4,920	4,470	4,040	3,630	3,320	2,920
		60	4,550	4,360	4,180	3,840	3,550	3,270	3,070	2,810
		90	3,780	3,650	3,520	3,330	3,150	2,980	2,860	2,700
9/16	C	30	6,750	6,600	6,410	6,010	5,590	5,100	4,670	3,880
		60	5,940	5,830	5,680	5,340	4,950	4,570	4,260	3,650
		90	5,130	5,050	4,960	4,680	4,320	4,070	3,850	3,470
	A and B	30	6,630	6,460	6,230	5,770	5,340	4,940	4,570	4,030
		60	5,700	5,550	5,360	5,030	4,700	4,420	4,180	3,840
		90	4,770	4,630	4,500	4,300	4,140	4,000	3,870	3,660
5/8	C	30	8,340	8,190	8,030	7,660	7,250	6,800	6,320	5,330
		60	7,370	7,250	7,110	6,790	6,450	6,080	5,670	5,000
		90	6,410	6,310	6,200	5,950	5,670	5,420	5,150	4,670

TABLE 58

Stringing Tensions for High-Tension Steel Cable

HEAVY LOADING DISTRICT

(At 30, 60 and 90°F. without load, the tensions being such that when loaded at 0°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C.)

Cable diameter (inches)	Grade of Const.	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
	A and B	30	2,990	2,840	2,660	2,250	1,850	1,420	1,130	800
		60	2,700	2,570	2,420	2,040	1,650	1,270	1,040	770
		90	2,420	2,310	2,180	1,830	1,450	1,140	960	740
5/16	C	30	3,670	3,590	3,500	3,240	2,860	2,430	2,060	1,230
		60	3,410	3,340	3,240	2,990	2,640	2,220	1,860	1,160
		90	3,160	3,080	2,990	2,750	2,420	2,000	1,670	1,090
	A and B	30	4,160	4,050	3,920	3,590	3,210	2,760	2,340	1,560
		60	3,810	3,690	3,560	3,260	2,890	2,480	2,110	1,490
		90	3,460	3,340	3,210	2,920	2,580	2,220	1,900	1,420
3/8	C	30	5,150	5,060	4,970	4,740	4,460	4,110	3,640	2,630
		60	4,800	4,710	4,620	4,400	4,120	3,790	3,330	2,500
		90	4,440	4,350	4,270	4,050	3,780	3,460	3,030	2,360
	A and B	30	6,130	6,020	5,910	5,640	5,320	4,960	4,550	3,400
		60	5,630	5,530	5,420	5,170	4,870	4,510	4,140	3,140
		90	5,120	5,030	4,940	4,680	4,390	4,060	3,730	2,930
7/16	C	30	7,500	7,450	7,380	7,200	6,950	6,670	6,350	5,260
		60	7,000	6,950	6,880	6,700	6,470	6,210	5,890	4,850
		90	6,490	6,450	6,380	6,200	5,980	5,710	5,430	4,440
	A and B	30	7,380	7,300	7,200	6,920	6,600	6,230	5,860	4,620
		60	6,770	6,700	6,600	6,350	6,040	5,700	5,350	4,270
		90	6,160	6,100	6,000	5,750	5,460	5,150	4,850	3,940
1/2	C	30	9,050	8,990	8,920	8,750	8,490	8,210	7,910	6,840
		60	8,440	8,380	8,320	8,150	7,900	7,630	7,330	6,340
		90	7,840	7,780	7,710	7,550	7,310	7,050	6,750	5,850
	A and B	30	9,900	9,830	9,750	9,510	9,200	8,850	8,500	7,310
		60	9,100	9,030	8,940	8,710	8,440	8,120	7,790	6,750
		90	8,300	8,240	8,150	7,930	7,670	7,370	7,080	6,210
9/16	C	30	12,080	12,020	11,960	11,800	11,600	11,310	11,020	10,110
		60	11,280	11,210	11,150	10,990	10,800	10,520	10,250	9,420
		90	10,440	10,390	10,330	10,180	10,000	9,750	9,500	8,710
	A and B	30	12,150	12,070	11,980	11,780	11,520	11,150	10,780	9,700
		60	11,160	11,090	11,010	10,820	10,580	10,240	9,890	8,950
		90	10,200	10,140	10,060	9,880	9,640	9,350	9,060	8,240
5/8	C	30	14,800	14,750	14,700	14,570	14,380	14,100	13,820	13,000
		60	13,820	13,780	13,720	13,580	13,380	13,140	12,890	12,100
		90	12,850	12,800	12,730	12,600	12,420	12,180	11,940	11,280

TABLE 59

Stringing Tensions for Bare Copper-Covered Steel Wire (Ordinary Grade)

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the wires will be stressed to 50 per cent of their ultimate strength.)

Size A. W. G. No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—						
			100	125	150	175	200	250	300
		°F.							
6	A and B	30	637	530	424	310	-------	-------	-------
		60	548	441	341	246	-------	-------	-------
		90	460	352	264	197	-------	-------	-------
4	A and B	30	1,037	964	863	752	635	400	274
		60	901	822	729	620	507	314	244
		90	764	685	594	495	400	275	222

TABLE 60

Stringing Tensions for Bare Copper-Covered Steel Cable

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the cable will be stressed to 50 per cent of its ultimate strength)

(Size inch)	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	800	1,000
		°F.								
5/16	A and B	30	2,260	2,105	1,885	1,455	1,065	------	------	------
		60	2,020	1,870	1,660	1,260	940	------	------	------
		90	1,790	1,605	1,440	1,105	840	------	------	------
3/8	A and B	30	3,600	3,435	3,285	2,920	2,505	2,100	1,586	------
		60	3,240	3,080	2,940	2,600	2,220	1,887	1,490	------
		90	2,885	2,740	2,595	2,290	1,970	1,700	1,405	------
7/16	A and B	30	4,309	4,280	4,110	3,760	3,350	2,930	2,320	1,995
		60	3,960	3,850	3,700	3,360	2,990	2,640	2,160	1,910
		90	3,530	3,425	3,285	2,985	2,665	2,380	2,010	1,835
1/2	A and B	30	5,585	5,480	5,330	5,015	4,625	4,230	3,485	2,985
		60	5,060	4,960	4,820	4,520	4,180	3,830	3,210	2,830
		90	4,560	4,465	4,325	4,055	3,745	3,460	2,960	2,685
9/16	A and B	30	6,845	6,790	6,660	6,380	6,020	5,635	4,875	4,260
		60	6,280	6,180	6,050	5,800	5,470	5,130	4,480	4,010
		90	5,650	5,570	5,460	5,220	4,940	4,660	4,140	3,810

TABLE 61

Stringing Tensions for Bare Stranded Aluminum

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the conductor will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			100	125	150	200	250	300	400	600
		°F.								
1	A and B	30	96	73	66	------	------	------	------	------
		60	66	59	53	------	------	------	------	------
		90	53	50	50	------	------	------	------	------
	C	30	267	149	99	------	------	------	------	------
		60	125	89	79	------	------	------	------	------
		90	73	69	66	------	------	------	------	------
0	A and B	30	199	125	108	95	87	87	83	------
		60	108	91	91	87	83	83	79	------
		90	79	75	75	75	75	75	75	------
	C	30	527	315	216	133	112	108	104	------
		60	273	162	133	112	104	104	100	------
		90	116	104	104	100	100	95	91	------
00	A and B	30	378	263	200	152	147	137	131	------
		60	173	152	142	131	131	131	126	------
		90	121	116	116	121	121	126	126	------
	C	30	709	593	420	252	194	179	168	152
		60	378	305	231	189	173	163	158	147
		90	173	168	158	158	152	152	147	147
000	A and B	30	640	488	370	251	218	211	198	185
		60	304	251	231	205	198	191	191	185
		90	165	165	172	172	178	185	185	185
	C	30	1,030	871	759	455	330	290	264	231
		60	601	482	409	304	264	251	244	224
		90	277	244	251	231	224	224	224	224
0000	A and B	30	938	747	623	398	349	324	291	282
		60	448	415	349	299	291	291	274	266
		90	232	232	241	249	257	266	266	266
	C	30	1,370	1,295	1,104	780	589	452	365	349
		60	772	722	631	465	415	365	349	340
		90	374	374	340	332	332	332	324	324

TABLE 62

Stringing Tensions for Bare Stranded Aluminum, Steel-Reinforced

HEAVY LOADING DISTRICT

(The tensions being such that when loaded at 0°F. the cable will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C.)

Size A. W. G. No.	Grade of Construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			100	150	200	300	400	500	600	700
		°F.								
4	A and B	32	170	210	110	------	------	------	------	------
		60	120	190	100	80	------	------	------	------
		120	100	110	90	60	------	------	------	------
	C	32	170	220	290	130	------	------	------	------
		60	120	190	230	120	------	------	------	------
		120	100	130	160	100	------	------	------	------
2	A and B	32	260	350	440	210	180	------	------	------
		60	210	290	370	190	170	------	------	------
		120	150	200	210	170	150	------	------	------
	C	32	260	370	470	530	280	------	------	------
		60	210	300	390	400	250	------	------	------
		120	150	200	260	300	120	------	------	------
1	A and B	32	320	440	580	400	280	230	------	------
		60	290	370	470	330	250	220	------	------
		120	200	250	300	280	220	210	------	------
	C	32	320	460	600	840	550	400	------	------
		60	290	380	490	700	490	380	------	------
		120	200	250	310	430	400	330	------	------
0	A and B	32	410	580	700	800	490	390	------	------
		60	330	450	580	620	420	380	------	------
		120	250	300	380	440	380	320	------	------
	C	32	500	590	730	1,080	1,000	630	500	------
		60	330	480	610	900	800	580	490	------
		120	250	320	400	550	600	510	450	------
00	A and B	32	510	700	890	1,250	880	620	520	------
		60	410	580	710	1,010	700	580	500	------
		120	300	390	470	610	540	500	480	------
	C	32	510	720	920	1,320	1,650	1,200	890	------
		60	410	600	780	1,120	1,310	970	780	------
		120	300	510	500	700	890	780	700	------
000	A and B	32	640	880	1,110	1,590	1,390	1,020	830	------
		60	520	710	900	1,290	1,090	880	790	------
		120	400	500	590	780	790	720	700	------
	C	32	640	900	1,170	1,700	2,200	1,820	1,420	1,160
		60	520	750	990	1,410	1,860	1,490	1,200	1,300
		120	400	400	630	890	1,130	1,080	990	920
0000	A and B	32	820	1,110	1,410	2,000	2,080	1,650	1,370	1,200
		60	680	900	1,130	1,600	1,680	1,360	1,200	1,100
		120	500	610	730	980	1,090	1,040	1,000	980
	C	32	820	1,140	1,490	1,130	1,800	1,750	1,300	940
		60	680	950	1,230	1,800	2,350	2,300	1,920	1,640
		120	500	650	810	1,120	1,430	1,520	1,420	1,370

Note. The above values were taken from blue prints supplied by the Aluminum Company of America.

Appendix B—Sags for Line Conductors Strung to the 2,000-Pound Limitation

By stringing conductors so that, under the worst assumed condition of loading, the tension in the conductor does not exceed 2,000 pounds, the required strength of cross arms and pins is similarly limited. (See rules 1261, D, 3, and 1261, E, 1.) Values of sag at a stringing temperature of 60° F. which will keep the tension when loaded within this limit are given for conductor sizes having an ultimate strength in excess of 4,000 pounds in Appendix C of the National Electrical Safety Code.

Appendix C—Mechanical Data for Wires and Cables

Copper: The following tables give the mechanical characteristics of copper wire and cable and are based on the standard specifications of the American Society for Testing Materials.

Hard-drawn copper manufactured in accordance with these specifications has an elastic limit of approximately 55 per cent of the ultimate strength given. Soft copper has no definite elastic limit, but it is below 5,000 pounds per square inch. It is not customarily stressed in excess of half its ultimate stress.

For purposes of calculation of sags and stresses, medium hard-drawn wire conforming with the A. S. T. M. specifications is considered as hard drawn. The breaking load of stranded cable has been taken as 90 per cent of the sum of the breaking loads of the individual strands.

The modulus of elasticity has been taken at 16,000,000 pounds per square inch for all grades of copper. The coefficient of linear thermal expansion per degree Fahrenheit has been taken as 9.6×10^{-6}. The weight of bare solid copper conductors has been taken as 3.854 pounds per square inch of cross section per foot of length; and of stranded conductors as 3.931 pounds. The weights of covered conductors are given in Table 72.

TABLE 63

Solid Copper Wire

Size A. W. G. No.	Diameter	Area of Conductor	Hard-drawn Wire		Soft Wire	
			Ultimate Stress	Breaking Load	Ultimate Stress	Breaking Load
	Inch	Sq. In.	Lbs./In.²	Pounds	Lbs./In.²	Pounds
0000	0.460	0.166	49,000	8,100	36,000	6,000
000	.410	.132	51,000	6,700	36,000	4,700
00	.365	.104	52,800	5,500	36,000	3,800
0	.325	.083	54,500	4,500	36,000	3,000
1	.289	.066	56,100	3,700	37,000	2,400
2	.258	.052	57,600	3,000	37,000	1,900
3	.229	.041	59,000	2,400	37,000	1,500
4	.204	.033	60,100	2,000	37,000	1,200
6	.162	.021	62,100	1,300	37,000	760
8	.128	.013	63,700	830	37,000	480
9	.114	.010	64,300	660	37,000	370
10	.102	.0082	64,900	530	38,500	310
12	.081	.0051	65,700	340	----------	----------
14	.064	.0032	66,200	210	----------	----------

TABLE 64

Stranded Copper Conductors

Size	External Diameter	Stranding	Area of Conductors	Breaking Load	
				Hard-drawn	Soft
Circular mills.	Inches		Sq. In.	Pounds	Pounds
1,000,000	1.15	61x0.128	0.785	45,000	----------
500,000	.813	37x .116	.392	22,700	13,000
450,000	.772	37x .110	.353	20,500	11,700
400,000	.728	37x .104	.314	18,300	10,500
350,000	.681	37x .097	.275	16,100	9,500
350,000	.678	19x .136	.275	15,700	9,100
300,000	.630	37x .090	.236	13,900	8,200
300,000	.628	19x .126	.236	13,500	7,800
250,000	.575	37x .082	.196	11,600	6,800
250,000	.573	19x .115	.196	11,300	6,500
A. W. G. No.:					
0000	.528	19x .106	.166	9,700	5,500
0000	.522	7x .174	.166	9,200	5,500
000	.470	19x .094	.132	7,700	4,600
000	.464	7x .155	.132	7,400	4,400
00	.418	19x .084	.104	6,100	3,600
00	.414	7x .138	.104	5,900	3,500
0	.373	19x .075	.083	4,900	2,850
0	.368	7x .123	.083	4,800	2,750
1	.332	19x .066	.066	3,900	2,300
1	.328	7x .109	.066	3,800	2,200
2	.292	7x .097	.052	3,050	1,800
3	.260	7x .087	.041	2,450	1,430
4	.232	7x .077	.033	1,950	1,130
5	.207	7x .069	.026	1,550	900
6	.184	7x .061	.021	1,230	710
7	.165	7x .055	.016	980	550
8	.146	7x .049	.013	780	450

Steel: Tables 65 and 66 give the mechanical characteristics of steel wire and cable of three grades, ordinary, Siemens–Martin, and high-tension. The ultimate stresses of the three are taken as 60,000, 75,000, and 125,000 pounds per square inch, respectively. The breaking load of stranded cable has in all cases been taken as 90 per cent of the sum of the breaking loads of the individual strands.

The coefficient of linear thermal expansion for steel has been taken as 6.7×10^{-6} per °F. The modulus of elasticity has been taken as 29,000,000 pounds per square inch for solid wires, and 21,000,000 pounds per square inch for cables. The weight of conductor per square inch of cross section is taken as 3.39 pounds per foot of length.

Steel from different sources may differ in physical properties, and when materials are used having properties different from those assumed, loads and sags should be computed from the actual values.

TABLE 65

Bare Solid Steel Wires

Size Stl. W. G. No.	Diameter	Area	Breaking Load		
			Ordinary	Siemens-Martin	High Tension Steel
	Inch	Sq. In.	Pounds	Pounds	Pounds
4	0.225	0.0400	2,400	3,000	5,000
6	.192	.0290	1,740	2,170	3,620
8	.162	.0206	1,240	1,560	2,570

TABLE 66

Stranded Bare Steel Conductors

Nominal size (inches)	Diameter	Area	Breaking Load		
			Ordinary	Siemens-Martin	High Tension Steel
	Inch	Sq. In.	Pounds	Pounds	Pounds
5/8	0.625	0.2356	12,720	15,900	26,500
9/16	.562	.1922	10,380	13,000	21,620
1/2	.500	.1443	7,790	9,740	16 230
7/16	.437	.1204	6,500	8,130	13,540
3/8	.375	.0832	4,490	5,620	9,360
5/16	.312	.0606	3,270	4,090	6,820
1/4	.250	.0352	1,900	2,380	3,960

Copper-Covered Steel: Tables 67, 68 and 69 give the mechanical characteristics of copper-covered steel conductors of standard tensile grade and extra-high-tensile grade. The tables were submitted by the Copperweld Steel Co. for copperweld wire, with supporting data. The breaking load

of stranded conductors has been taken as 90 per cent of the sum of the breaking loads of the individual strands.

Sags have been computed for standard tensile grade only. The coefficient of linear thermal expansion for these conductors has been taken as 7.2×10^{-6} per °F. The modulus of elasticity for solid wires has been taken as 20,000,000 pounds per square inch. For stranded cables, the value of the modulus varies with size as follows:

5/8 inch diameter, 15,600,000 pounds per square inch.
9/16 inch diameter, 16,100,000 pounds per square inch.
1/2 inch diameter, 17,000,000 pounds per square inch.
7/16 inch diameter, 17,800,000 pounds per square inch.
3/8 inch diameter, 18,600,000 pounds per square inch.
5/16 inch diameter, 19,500,000 pounds per square inch.

The weight of conductor per square inch of cross section is taken as 3.53 pounds per foot of length.

TABLE 67

Solid Bare Copper-Covered Steel Conductors

Size A. W. G. No.	Diameter	Area	Breaking load	
			Standard	Extra-high Tensile
	Inch	Sq. Inch	Pounds	Pounds
0000	0.460	0.166	9,850	----------
000	.410	.132	8,280	----------
00	.365	.104	6,850	----------
0	.325	.083	5,700	----------
1	.289	.066	4,800	----------
2	.258	.052	4,000	7,300
3	.229	.041	3,200	5,780
4	.204	.033	2,650	4,600
5	.182	.026	2,200	3,640
6	.162	.021	1,800	2,880
7	.144	.016	1,430	2,290
8	.128	.013	1,200	1,820
9	.114	.0103	970	----------
10	.102	.0082	800	----------

TABLE 68

Stranded Bare Copper-Covered Steel Conductors—Standard Tensile Grade

Size A. W. G. No.	Nominal Diameter	Stranding	Area	Breaking Load
	Inch		Sq. In.	Pounds
	5/8	7 No. 4	0.229	18,550
	9/16	7 No. 5	.182	15,400
0000	----------	7x	.166	14,300
	1/2	7 No. 6	.144	12,600
000	----------	7x	.132	11,640
	7/16	7 No. 7	.114	10,160
00	----------	7x	.105	9,460
	3/8	7 No. 8	.091	8,400
0	----------	7x	.0829	7,780
	11/32	7 No. 9	.0719	6,790
	5/16	7 No. 10	.0571	5,600

x Means special size wire, not an A. W. G. size.

TABLE 69

Stranded Bare Copper-Covered Steel Conductors—Extra-High Tensile Grade

Size A. W. G. No.	Nominal Diameter	Stranding	Area	Breaking load
	Inch		Sq. In.	Pounds
	7/8	19 No. 5	0.495	62,240
	13/16	19 No. 6	.392	49,250
	3/4	19x	.354	44,600
	23/32	19 No. 7	.311	39,160
	11/16	19x	.275	34,800
	5/8	19 No. 8	.246	31,120
	5/8	7 No. 4	.229	28,980
	9/16	7 No. 5	.182	22,930
		7x	.166	20,940
0000	1/2	7 No. 6	.144	18,200
		7x	.132	16,600
000	7/16	7 No. 7	.114	14,420
		7x	.105	13,160
00	3/8	7 No. 8	.091	11,460

x Means Special size wire, not an A. W. G. size.

Aluminum: Table 70 gives the mechanical characteristics of stranded aluminum conductors. The coefficient of linear thermal expansion for aluminum has been taken as 12.8×10^{-6} per degree Fahrenheit, and the modulus of elasticity as 9,000,000 pounds per square inch. The weight of conductor is 1.194 pounds per square inch of cross section for a length of 1 foot.

Table 71 gives the mechanical characteristics of aluminum cable having a steel core. The virtual coefficient of expansion, the modulus of elasticity, and the weight per unit length vary with the size of cable. For cables of sizes 4/0 to 6, A. W. G., the coefficient of thermal expansion has been taken as 10.5×10^{-6} per degree Fahrenheit; the modulus of elasticity as 12,000,000 pounds per square inch; and the weight per unit cross section as 1.52 pounds per foot of length.

TABLE 70

Stranded Aluminum Conductors

Size	Diameter	Area	Usual Stranding	Copper Equivalent	Elastic Limit	Breaking load
Circular mills.	Inches	Sq. In.		c. m.	Pounds	Pounds
874,500	1.077	0.687	37x0.154	550,000	9,600	14,800
795,000	1.026	.624	37x .146	500,000	8,750	13,500
750,000	.994	.589	37x .142	472,000	8,250	12,700
715,500	.974	.562	37x .139	450,000	7,870	12,100
636,000	.918	.500	37x .131	400,000	7,000	10,800
556,500	.856	.437	19x .171	350,000	6,120	9,450
500,000	.810	.393	19x .162	314,500	5,500	8,500
477,000	.793	.375	19x .158	300,000	5,240	8,100
397,500	.724	.312	19x .145	250,000	4,370	6,750
300,000	.621	.236	19x .126	188,800	3,300	5,100
				A. W. G. No.		
336,400	.657	.264	19x .133	0000	3,700	5,700
266,800	.586	.209	7x .195	000	2,940	4,550
A. W. G. No.:						
0000	.522	.166	7x .174	00	2,330	3,570
000	.464	.132	7x .155	0	1,845	2,860
00	.414	.104	7x .138	1	1,465	2,270
0	.368	.083	7x .123	2	1,160	1,790
1	.328	.066	7x .109	3	920	1,420

TABLE 71

Aluminum Cables, Steel-Reinforced

Size	Equivalent Copper	Diameter	Stranding		Total Area	Breaking Load
			Aluminum	Steel		
Circular mills:	c. m.	Inches			Sq. In.	Pounds
795,000	500,000	1.093	54x0.1214	7x0.1214	0.7060	25,150
715,500	450,000	1.036	54x .1151	7x .1151	.6350	22,680
636,000	400,000	.977	54x .1085	7x .1085	.5640	20,060
477,000	300,000	.883	30x .1261	7x .1261	.4020	20,700
397,500	250,000	.806	30x .1151	7x .1151	.3850	17,250
	A. W. G. No.					
336,400	0000	.741	30x .1059	7x .1059	.3260	14,580
266,800	000	.633	6x .2108	7x .0705	.2370	8,450
A. W. G. No.						
0000	00	.564	6x .1880	1x .1880	.1939	7,590
000	0	.501	6x .1670	1x .1670	.1537	5,995
00	1	.447	6x .1490	1x .1490	.1219	4,770
0	2	.398	6x .1327	1x .1327	.0967	3,780
1	3	.355	6x .1182	1x .1182	.0766	3,000
2	4	.316	6x .1052	1x .1052	.0608	2,394
3	5	.281	6x .0938	1x .0938	.0482	1,890
4	6	.250	6x .0834	1x .0834	.0383	1,500
5	7	.223	6x .0743	1x .0743	.0303	1,183
6	8	.198	6x .0661	1x .0661	.0240	940

The values given in these tables were submitted by the Aluminum Co. of America with supporting data. The breaking load of stranded conductors has been taken as 90 per cent of the sum of the breaking loads of the individual strands, including the steel core where used.

Sags in table 47 and tensions in table 61 were supplied by the Aluminum Company of America. The breaking loads of the cables were used and not the 90% value listed above.

Appendix D Loads Upon Conductors and Supports

Table 72 gives the weights of conductors of various sizes and materials, with and without ice loading. Table 73 gives the transverse and resultant loads of the same conductors based on the assumed loadings of section 25. The over-all diameters of covered wires supplied by different manufacturers are not the same and hence average values have been chosen. This is also true of the sizes of strands which make up steel cables.

TABLE 72

Vertical Loads on Conductor Supports

Size of Conductors	Diameter over all	Weight of	
		Conductor +0.5 in. of ice=heavy	Conductor only=light
	Inch	Lbs./Ft.	Lbs./Ft.
Bare solid copper.			
A. W. G. No.—			
12	0.081	0.381	0.020
10	.102	.406	.031
8	.128	.440	.050
6	.162	.491	.079
4	.204	.564	.126
3	.229	.612	.159
2	.258	.672	.201
1	.289	.744	.253
0	.325	.832	.319
00	.365	.943	.405
000	.410	1.075	.509
0000	.460	1.237	.640
Bare stranded copper.			
A. W. G. No.—			
6	.18	.505	.083
4	.23	.580	.126
3	.26	.634	.161
2	.29	.696	.204
1	.33	.775	.259
0	.37	.867	.326
00	.41	.979	.413
000	.46	1.116	.519
0000	.52	1.287	.652
Cir. mils—			
250,000	0.57	1.436	0.770
300,000	.63	1.630	.928
350,000	.68	1.815	1.081
400,000	.73	1.992	1.234
450,000	.77	2.177	1.388
500,000	.81	2.355	1.541
1,000,000	1.15	4.112	3.086
T. B. W. P. solid copper.			
A. W. G. No.—			
12	.21	.476	.035
10	.25	.519	.053
8	.26	.547	.075
6	.32	.622	.112
4	.38	.711	.164
3	.41	.760	.200
2	.44	.840	.260
1	.47	.919	.316

TABLE 72

Vertical Loads on Conductor Supports—Continued

Size of Conductors	Diameter over all	Weight of	
		Conductor +0.5 in. of ice=heavy	Conductor only=light
	Inch	Lbs./Ft.	Lbs./Ft.
T. B. W. P. solid copper—Con.			
A. W. G. No—			
0	.50	1.029	.407
00	.53	1.143	.502
000	.62	1.326	.630
0000	.65	1.482	.767
T. B. W. P. stranded copper.			
A. W. G. No.—			
2	.444	.857	.270
1	.518	.961	.328
0	.620	1.120	.424
00	.662	1.245	.522
000	.734	1.421	.654
0000	.785	1.599	.800
Cir. mils—			
250,000	.862	1.832	.985
350,000	.978	2.264	1.345
500,000	1.108	2.894	1.894
750,000	1.343	3.968	2.822
1,000,000	1.531	4.937	3.674
Bare solid steel.			
Stl. W. G. No.—			
8	.162	.482	.070
6	.192	.528	.098
4	.225	.586	.135
Bare stranded steel.			
1/4 inch	.250	.586	.119
5/16 inch	.312	.711	.205
3/8 inch	.375	.826	.282
7/16 inch	.437	.991	.408
1/2 inch	.500	1.111	.489
9/16 inch	.562	1.312	.652
5/8 inch	.625	1.498	.799
Solid bare copper-covered steel.			
A. W. G. No.—			
10	0.102	0.402	0.029
8	.128	.437	.046
6	.162	.485	.073
4	.204	.554	.116
Stranded bare copper-covered steel.			
5/16 inch	.306	.710	.209
3/8 inch	.384	.882	.332
7/16 inch	.432	.998	.418
1/2 inch	.486	1.139	.526
9/16 inch	.546	1.313	.663
Stranded aluminum, bare.			
A. W. G. No.—			
2	.293	.554	.062
1	.328	.592	.079
0	.368	.637	.099
00	.414	.692	.125
000	.464	.756	.158
0000	.522	.832	.198
Bare stranded aluminum, steel—reinforced.			
A. W. G. No.—			
4	.250	.523	.058
2	.316	.598	.092
1	.355	.647	.117
0	.398	.704	.147
00	.447	.772	.185
000	.501	.853	.232
0000	.564	.954	.294
Cir. mils—			
336,400	.741	1.297	.527
477,000	.883	1.605	.747

TABLE 73

Transverse and Resultant Loads on Conductors and Supports in Heavy and Light Loading Districts

(Pounds per conductor per linear foot.)

Size of conductor	Transverse force on conductor with ice covering (if any)		Resultant force on conductor due to wt. & wind	
	Heavy	Light	Heavy	Light
Bare solid copper.				
A. W. G. No.—				
12	0.721	0.081	0.815	0.084
10	.735	.102	.840	.107
8	.752	.128	.872	.137
6	.775	.162	.918	.180
4	0.803	0.204	0.986	0.240
3	.820	.229	1.023	.279
2	.839	.258	1.075	.327
1	.860	.289	1.137	.384
0	.884	.325	1.214	.456
00	.910	.365	1.310	.545
000	.940	.410	1.428	.653
0000	.974	.460	1.574	.788
Bare stranded copper.				
A. W. G. No.—				
6	.787	.180	.935	.198
4	.820	.230	1.005	.262
3	.840	.260	1.053	.306
2	.860	.290	1.106	.355
1	.887	.330	1.178	.420
0	.914	.370	1.260	.493
00	.940	.410	1.357	.582
000	.974	.460	1.481	.693
0000	1.014	.520	1.638	.834
Cir. mils—				
250,000	1.047	.570	1.777	.958
300,000	1.087	.630	1.960	1.121
350,000	1.121	.680	2.133	1.277
400,000	1.154	.730	2.308	1.434
450,000	1.181	.770	2.477	1.587
500,000	1.207	.810	2.646	1.741
1,000,000	1.434	1.150	4.355	3.203
T. B. W. P. solid copper.				
A. W. G. No.—				
12	.807	.210	.937	.213
10	.834	.250	.987	.255
8	.840	.260	1.003	.270
6	.889	.320	1.078	.339
4	.920	.380	1.163	.414
3	.940	.410	1.213	.456
2	.960	.440	1.276	.511
1	.980	.470	1.344	.566
0	1.000	.500	1.435	.645
00	1.020	.530	1.532	.730
000	1.080	.620	1.711	.872
0000	1.100	.650	1.846	1.005
T. B. W. P. stranded copper.				
A. W. G. No.—				
2	.961	.444	1.289	.520
1	1.012	.518	1.396	.613
0	1.080	.620	1.557	.751
00	1.109	.662	1.667	.843
000	1.157	.734	1.832	.983
0000	1.191	.785	1.994	1.121
Cir. mil's—				
250,000	1.241	0.862	2.213	1.309
350,000	1.319	978	2.620	1.663
500,000	1.403	1.108	3.217	2.194
750,000	1.563	1.343	4.265	3.125
1,000,000	1.688	1.531	5.218	3.980
Bare solid steel.				
Stl. W. G. No.				
8	.775	.162	.912	.176
6	.795	.192	.955	.216
4	.817	.225	1.006	.263

TABLE 73

Transverse and Resultant Loads on Conductors and Supports in Heavy and Light Loading Districts—Continued

Size of Conductor	Transverse force on conductor with ice covering (if any)		Resultant force on conductor due to wt. & wind	
	Heavy	Light	Heavy	Light
Bare stranded steel.				
1/4 inch	.833	.250	1.018	.277
5/16 inch	.875	.312	1.126	.374
3/8 inch	.917	.375	1.234	.469
7/16 inch	.958	.437	1.379	.598
1/2 inch	1.000	.500	1.495	.699
9/16 inch	1.042	.562	1.675	.861
5/8 inch	1.083	.625	1.849	1.014
Solid bare copper-covered steel.				
A. W. G. No.				
10	.735	.102	.838	.106
8	.752	.128	.870	.136
6	.775	.162	.914	.178
4	.803	.204	.975	.235
Stranded bare copper-covered steel.				
5/16 inch	.871	.306	1.124	.370
3/8 inch	.923	.384	1.276	.508
7/16 inch	.955	.432	1.381	.601
1/2 inch	.991	.486	1.510	.716
9/16 inch	1.031	.546	1.670	.859
Bare stranded aluminum.				
A. W. G. No.—				
2	.862	.293	1.020	.300
1	.886	.328	1.065	.337
0	.912	.368	1.113	.380
00	.943	.414	1.170	.432
000	.976	.464	1.234	.489
0000	1.015	.522	1.312	.557
Bare stranded aluminum steel-reinforced.				
A. W. G. No.—				
4	.834	.250	.984	.257
2	.878	.316	1.062	.329
1	.904	.355	1.112	.374
0	.932	.398	1.168	.424
00	.965	.447	1.236	.484
000	1.001	.501	1.315	.552
0000	1.043	.564	1.414	.636
Cir. mils—				
336,400	1.161	.741	1.741	.909
477,000	1.256	.883	2.038	1.157

Appendix E—Wood Poles, Moments of Resistance of Poles

The resisting moments of wood poles of various ground-line circumferences are given in the accompanying tables for each value of allowable fiber stress recognized in Table 20, for poles when installed. The tables are applicable to all woods having the recognized ultimate fiber stresses mentioned in the titles. Table 74 applies especially to southern yellow pine (creosoted); Table 75 applies especially to chestnut; Table 76 applies especially to western red cedar; Table 77 applies especially to cypress; and Table 78 to northern white cedar and redwood.

Southern yellow pine should not be used for supporting structures unless first given a preservative treatment, as

otherwise the rapid deterioration will require early replacement.

The resisting moment of a pole is expressed by the well-known structural formula

$$M = \frac{fI}{y}$$

where

M = moment.
f = allowable fiber stress.
$\frac{I}{y}$ = section modulus.

For poles with circular cross section, this formula may be expressed in terms of the allowable fiber stress and circumference as follows:

$$M = 0.0002638 f G^3$$

where

M = moment in pound-feet.
f = allowable fiber stress in pounds per square inch.
G = circumference of the pole at ground line in inches.

While the ground-line section may not be the most stressed section in poles with considerable taper, it is so regarded here. Since the wood usually deteriorates most rapidly at this point, it is here that sufficient strength must be provided.

The last column in each of the Tables 74, 75, 76, 77 and 78 is for fiber stress 50 per cent greater than the ultimate. This value is included because, in construction of grade C, poles are permitted to deteriorate to such a point, before replacement is called for, that the factor of safety is only two-thirds. This factor is based, however, upon an assumed loading which in some localities is experienced only at rare intervals, and by some individual poles perhaps never. Such a condition does not, therefore, indicate failure.

TABLE 74

Resisting Moments for Poles of Woods Having an Ultimate Fiber Stress of 7,400 Pounds Per Square Inch (Southern Yellow Pine, Creosoted)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)						
	2,470	2,960	3,700	4,440	5,550	7,400	11,100
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
20	5,200	6,250	7,800	9,350	11,700	15,600	23,450
21	6,050	7,250	9,050	10,850	13,550	18,100	27,100
22	6,950	8,300	10,400	12,450	15,600	20,800	31,200
23	7,950	9,500	11,900	14,250	17,800	23,750	35,650
24	9,000	10,800	13,500	16,200	20,250	27,000	40,500
25	10,200	12,200	15,250	18,300	22,900	30,500	45,750
26	11,450	13,700	17,150	20,600	25,750	34,300	51,450
27	12,850	15,350	19,200	23,050	28,800	38,400	57,650
28	14,300	17,150	21,450	25,700	32,150	42,850	64,300
29	15,900	19,050	23,800	28,550	35,700	47,600	71,400
30	17,600	21,100	26,350	31,600	39,550	52,700	79,050
31	19,400	23,250	29,100	34,900	43,600	58,150	87,250
32	21,350	25,600	32,000	38,400	48,000	63,950	95,950
33	23,400	28,050	35,100	42,100	52,600	70,150	105,250
34	25,600	30,700	38,350	46,050	57,550	76,750	115,100
35	27,950	33,500	41,850	50,200	62,750	83,700	125,550
36	30,400	36,450	45,550	54,650	68,300	91,100	136,600
37	33,000	39,550	49,450	59,350	74,150	98,900	148,300
38	35,750	42,850	53,550	64,250	80,350	107,100	160,700
39	38,650	46,300	57,900	69,500	86,850	115,800	173,700
40	41,700	49,950	62,450	74,950	93,700	124,950	187,400
41	44,900	53,800	67,250	80,750	100,900	134,550	201,800
42	48,250	57,850	72,300	86,800	108,450	144,650	216,950
43	51,800	62,100	77,600	93,100	116,400	155,200	232,800
44	55,500	66,500	83,150	99,750	124,700	166,300	249,450
45	59,400	71,150	88,950	106,750	133,400	177,900	266,850
46	63,400	76,000	95,000	114,000	142,500	190,000	285,000
47	67,650	81,050	101,350	121,600	152,000	202,650	304,000
48	72,050	86,350	107,950	129,550	161,900	215,900	323,850
49	76,650	91,850	114,850	137,800	172,250	229,650	344,500
50	81,450	97,600	122,000	146,400	183,000	244,000	366,000
51	86,450	103,600	129,500	155,350	194,200	258,950	388,450
52	91,600	109,800	137,250	164,700	205,850	274,500	411,750
53	97,000	116,250	145,300	174,400	217,950	290,650	435,950
54	102,600	122,950	153,700	184,450	230,550	307,400	461,100
55	108,400	129,900	162,400	194,850	243,600	324,800	487,200
56	114,450	137,150	171,400	205,700	257,100	342,800	514,250
57	120,650	144,600	180,750	216,900	271,150	361,500	542,300
58	127,150	152,350	190,450	228,550	285,650	380,900	571,300
59	133,800	160,350	200,450	240,550	300,700	400,900	601,400
60	140,750	168,650	210,850	253,000	316,250	421,650	632,500
61	147,900	177,250	221,550	265,850	332,300	443,100	664,650
62	155,300	186,100	232,600	279,150	348,950	465,250	697,850
63	162,950	195,250	244,050	292,850	366,100	488,100	732,200
64	170,800	204,700	255,850	307,050	383,800	511,750	767,600
65	178,950	214,450	268,050	321,650	402,100	536,100	804,150
66	187,350	224,500	280,600	336,750	420,900	561,250	841,850
67	195,950	234,850	293,550	352,300	440,350	587,150	880,700
68	204,900	245,500	306,900	368,300	460,350	613,800	920,700
69	214,050	256,600	320,650	384,750	480,950	641,300	961,950
70	223,500	267,850	334,800	401,750	502,200	669,600	1,004,350
71	233,200	279,450	349,350	419,200	524,000	698,700	1,048,050
72	243,200	291,450	364,300	437,150	546,450	728,600	1,092,950
73	253,500	303,750	379,700	455,650	569,550	759,400	1,139,100
74	264,050	316,400	395,500	474,650	593,300	791,050	1,186,550
75	274,900	329,400	411,800	494,150	617,650	823,550	1,235,350
76	286,050	342,750	428,450	514,150	642,700	856,950	1,285,400
77	297,450	356,500	445,600	534,700	668,400	891,200	1,336,800
78	309,200	370,550	463,200	555,850	694,800	926,400	1,389,550
79	321,250	385,000	481,250	577,500	721,850	962,450	1,443,700
80	333,600	399,800	499,750	599,700	749,600	999,500	1,499,250

TABLE 75

Resisting Moments for Poles of Woods Having an Ultimate Fiber Stress of 6,000 Pounds Per Square Inch (Chestnut)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)							
	1,500	2,000	2,400	3,000	3,600	4,500	6,000	9,000
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
20	3,150	4,200	5,050	6,350	7,600	9,500	12,650	19,000
21	3,650	4,900	5,850	7,350	8,800	11,000	14,650	22,000
22	4,200	5,700	6,850	8,550	10,200	12,750	16,950	25,400
23	4,800	6,400	7,700	9,650	11,550	14,450	19,250	28,900
24	5,450	7,300	8,750	10,950	13,150	16,400	21,900	32,800
25	6,200	8,250	9,900	12,350	14,850	18,550	24,750	37,100
26	6,950	9,250	11,150	13,900	16,700	20,850	27,800	41,750
27	7,800	10,400	12,450	15,600	18,700	23,350	31,150	46,750
28	8,700	11,600	13,900	17,350	20,850	26,050	34,750	52,100
29	9,650	12,850	15,450	19,300	23,150	28,950	38,600	57,900
30	10,700	14,250	17,100	21,350	25,650	32,050	42,750	64,100
31	11,800	15,700	18,850	23,600	28,300	35,350	47,150	70,750
32	12,950	17,300	20,750	25,950	31,100	38,800	51,850	77,800
33	14,200	18,950	22,750	28,450	34,150	42,650	56,900	85,300
34	15,550	20,750	24,900	31,100	37,350	46,650	62,200	93,300
35	16,950	22,600	27,150	33,950	40,700	50,900	67,850	101,800
36	18,450	24,600	29,550	36,900	44,300	55,400	73,850	110,750
37	20,050	26,700	32,050	40,100	48,100	60,150	80,150	120,250
38	21,700	28,950	34,750	43,450	52,100	65,150	86,850	130,300
39	23,450	31,300	37,550	46,950	56,350	70,400	93,900	140,850
40	25,300	33,750	40,500	50,650	60,800	75,950	101,300	151,950
41	27,250	36,350	43,650	54,550	65,450	81,800	109,100	163,650
42	29,300	39,100	46,900	58,650	70,350	87,950	117,250	175,900
43	31,450	41,950	50,350	62,900	75,500	94,400	125,850	188,750
44	33,700	44,950	53,950	67,400	80,900	101,100	134,850	202,250
45	36,050	48,100	57,700	72,100	86,550	108,150	144,250	216,350
46	38,500	51,350	61,650	77,050	92,450	115,550	154,050	231,100
47	41,100	54,800	65,750	82,150	98,600	123,250	164,350	246,500
48	43,750	58,350	70,000	87,500	105,050	131,300	175,050	262,550
49	46,550	62,050	74,500	93,100	111,750	139,650	186,200	279,300
50	49,450	65,950	79,150	98,950	118,700	148,400	197,850	296,800
51	52,500	70,000	84,000	105,000	126,000	157,450	209,950	314,950
52	55,650	74,200	89,000	111,300	133,550	166,900	222,550	333,850
53	58,900	78,550	94,250	117,800	141,400	176,750	235,650	353,450
54	62,300	83,100	99,700	124,600	149,550	186,950	249,250	373,850
55	65,850	87,800	105,350	131,650	158,000	197,500	263,350	395,000
56	69,500	92,650	111,200	139,000	166,800	208,450	277,950	416,950
57	73,300	97,700	117,250	146,550	175,850	219,850	293,100	439,700
58	77,200	102,950	123,550	154,400	185,300	231,600	308,800	463,250
59	81,250	108,350	130,050	162,550	195,050	243,800	325,050	487,600
60	85,450	113,950	136,750	170,950	205,150	256,400	341,900	512,850
61	89,800	119,750	143,700	179,650	215,550	269,450	359,250	538,900
62	94,300	125,750	150,900	188,600	226,350	282,900	377,250	565,850
63	98,950	131,900	158,300	197,900	237,450	296,850	395,750	593,650
64	103,750	138,300	165,950	207,450	248,950	311,200	414,900	622,400
65	108,650	144,900	173,850	217,350	260,800	326,000	434,700	652,000
66	113,750	151,700	182,000	227,500	273,050	341,300	455,050	682,550
67	119,000	158,700	190,400	238,000	285,650	357,050	476,050	714,050
68	124,400	165,900	199,050	248,850	298,600	373,250	497,700	746,500
69	130,000	173,300	208,000	260,000	312,000	389,950	519,950	779,950
70	135,750	180,950	217,150	271,450	325,750	407,200	542,900	814,350
71	141,650	188,850	226,600	283,250	339,900	424,900	566,500	849,750
72	147,700	196,950	236,300	295,400	354,450	443,100	590,800	886,150
73	153,950	205,250	246,300	307,850	369,450	461,800	615,750	923,600
74	160,350	213,800	256,550	320,700	384,850	481,050	641,400	962,100
75	166,950	222,600	267,100	333,850	400,650	500,800	667,750	1,001,600
76	173,700	231,600	277,900	347,400	416,900	521,100	694,800	1,042,200
77	180,650	240,850	289,050	361,300	433,550	541,950	722,600	1,083,900
78	187,800	250,350	300,450	375,550	450,650	563,350	751,100	1,126,700
79	195,100	260,150	312,150	390,200	468,250	585,300	780,400	1,170,550
80	202,600	270,150	324,150	405,200	486,250	607,800	810,400	1,215,600

TABLE 76

Resisting Moments for Poles of Woods Having an Ultimate Fiber Stress of 5,600 Pounds Per Square Inch (Western Red Cedar)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)							
	1,400	1,870	2,240	2,800	3,360	4,200	5,600	8,400
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
20	2,950	3,950	4,750	5,900	7,100	8,850	11,800	17,750
21	3,400	4,550	5,450	6,850	8,200	10,250	13,700	20,500
22	3,950	5,250	6,300	7,850	9,450	11,800	15,750	23,600
23	4,500	6,000	7,200	9,000	10,800	13,500	17,950	26,950
24	5,100	6,800	8,150	10,200	12,250	15,300	20,400	30,650
25	5,750	7,700	9,250	11,550	13,850	17,300	23,100	34,600
26	6,500	8,650	10,400	13,000	15,600	19,450	25,950	38,950
27	7,250	9,700	11,650	14,550	17,450	21,800	29,100	43,600
28	8,100	10,850	12,950	16,200	19,450	24,300	32,450	48,650
29	9,000	12,050	14,400	18,000	21,600	27,000	36,050	54,050
30	9,950	13,300	15,950	19,950	23,950	29,900	39,900	59,850
31	11,000	14,700	17,600	22,000	26,400	33,000	44,000	66,000
32	12,100	16,150	19,350	24,200	29,050	36,300	48,400	72,600
33	13,250	17,750	21,250	26,550	31,850	39,800	53,100	79,650
34	14,500	19,400	23,250	29,050	34,850	43,550	58,050	87,100
35	15,850	21,150	25,350	31,650	38,000	47,500	63,350	95,000
36	17,250	23,000	27,550	34,450	41,350	51,700	68,900	103,400
37	18,700	25,000	29,950	37,400	44,900	56,100	74,850	112,250
38	20,250	27,050	32,400	40,550	48,650	60,800	81,050	121,600
39	21,900	29,250	35,050	43,800	52,600	65,700	87,650	131,450
40	23,650	31,550	37,800	47,250	56,750	70,900	94,550	141,800
41	25,450	34,000	40,750	50,900	61,100	76,350	101,800	152,700
42	27,350	36,550	43,800	54,700	65,650	82,100	109,450	164,150
43	29,350	39,200	47,000	58,750	70,450	88,100	117,450	176,200
44	31,450	42,000	50,350	62,900	75,500	94,400	125,850	188,750
45	33,650	44,950	53,850	67,300	80,750	100,950	134,600	201,950
46	35,950	48,000	57,500	71,900	86,300	107,850	143,800	215,700
47	38,350	51,200	61,350	76,700	92,050	115,050	153,400	230,050
48	40,850	54,550	65,350	81,700	98,050	122,550	163,400	245,050
49	43,450	58,050	69,500	86,900	104,300	130,350	173,800	260,700
50	46,150	61,650	73,850	92,350	110,800	138,500	184,650	277,000
51	49,000	65,450	78,400	98,000	117,600	147,000	195,950	293,950
52	51,950	69,350	83,100	103,850	124,650	155,800	207,700	311,600
53	55,000	73,450	87,950	109,950	131,950	164,950	219,950	329,900
54	58,150	77,700	93,050	116,300	139,550	174,450	232,600	348,950
55	61,450	82,050	98,300	122,900	147,450	184,350	245,800	368,650
56	64,850	86,650	103,750	129,700	155,650	194,600	259,450	389,150
57	68,400	91,350	109,450	136,800	164,150	205,200	273,600	410,350
58	72,050	96,250	115,300	144,100	172,950	216,200	288,250	432,350
59	75,850	101,300	121,350	151,700	182,050	227,550	303,400	455,100
60	79,750	106,550	127,650	159,550	191,450	239,300	319,100	478,650
61	83,850	111,950	134,150	167,650	201,200	251,500	335,300	502,950
62	88,000	117,550	140,850	176,050	211,250	264,050	352,100	528,100
63	92,350	123,350	147,750	184,700	221,650	277,050	369,400	554,100
64	96,800	129,300	154,900	193,600	232,350	290,450	387,250	580,900
65	101,400	135,450	162,300	202,850	243,400	304,250	405,700	608,550
66	106,200	141,800	169,900	212,350	254,850	318,550	424,700	637,050
67	111,100	148,350	177,700	222,150	266,600	333,250	444,300	666,450
68	116,150	155,100	185,800	232,250	278,700	348,400	464,500	696,750
69	121,300	162,050	194,100	242,650	291,200	363,950	485,300	727,950
70	126,700	169,200	202,700	253,350	304,000	380,050	506,700	760,050
71	132,200	176,550	211,500	264,350	317,250	396,550	528,750	793,100
72	137,850	184,150	220,550	275,700	330,850	413,550	551,400	827,100
73	143,650	191,900	229,850	287,350	344,800	431,000	574,700	862,050
74	149,650	199,900	239,450	299,300	359,200	448,950	598,650	897,950
75	155,800	208,100	249,300	311,600	373,950	467,400	623,250	934,850
76	162,100	216,550	259,400	324,250	389,100	486,350	648,500	972,750
77	168,600	225,200	269,750	337,200	404,650	505,800	674,450	1,011,650
78	175,250	234,100	280,400	350,500	420,650	525,800	701,050	1,051,550
79	182,100	243,200	291,350	364,200	437,000	546,250	728,350	1,092,550
80	189,100	252,550	302,550	378,200	453,800	567,300	756,350	1,134,550

TABLE 77

Resisting Moments for Poles of Woods With an Ultimate Fiber Stress of 5,000 Pounds Per Square Inch (Other Yellow Pine, Cypress)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)							
	1,250	1,670	2,000	2,500	3,000	3,750	5,000	7,500
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
20	2,650	3,500	4,200	5,300	6,350	7,900	10,550	15,850
21	3,050	4,100	4,900	6,100	7,350	9,150	12,200	18,300
22	3,500	4,700	5,600	7,000	8,450	10,550	14,050	21,050
23	4,000	5,350	6,400	8,000	9,650	12,050	16,050	24,050
24	4,550	6,100	7,300	9,100	10,950	13,700	18,250	27,350
25	5,150	6,900	8,250	10,300	12,350	15,450	20,600	30,900
26	5,800	7,750	9,250	11,600	13,900	17,400	23,200	34,750
27	6,500	8,650	10,400	13,000	15,600	19,450	25,950	38,950
28	7,250	9,650	11,600	14,500	17,350	21,700	28,950	43,450
29	8,050	10,750	12,850	16,100	19,300	24,150	32,150	48,250
30	8,900	11,900	14,250	17,800	21,350	26,700	35,600	53,400
31	9,800	13,100	15,700	19,650	23,600	29,450	39,300	58,950
32	10,800	14,450	17,300	21,600	25,950	32,400	43,200	64,850
33	11,850	15,850	18,950	23,700	28,450	35,550	47,400	71,100
34	12,950	17,300	20,750	25,900	31,100	38,900	51,850	77,750
35	14,150	18,900	22,600	28,300	33,950	42,400	56,550	84,850
36	15,400	20,550	24,600	30,750	36,900	46,150	61,550	92,300
37	16,700	22,300	26,700	33,400	40,100	50,100	66,800	100,200
38	18,100	24,150	28,950	36,200	43,450	54,300	72,400	108,550
39	19,550	26,150	31,300	39,100	46,950	58,700	78,250	117,350
40	21,100	28,200	33,750	42,200	50,650	63,300	84,400	126,600
41	22,750	30,350	36,350	45,450	54,550	68,200	90,900	136,350
42	24,450	32,650	39,100	48,850	58,650	73,300	97,700	146,600
43	26,200	35,050	41,950	52,450	62,900	78,650	104,850	157,300
44	28,100	37,550	44,950	56,200	67,400	84,250	112,350	168,550
45	30,050	40,150	48,100	60,100	72,100	90,150	120,200	180,300
46	32,100	42,900	51,350	64,200	77,050	96,300	128,400	192,600
47	34,250	45,750	54,800	68,450	82,150	102,700	136,950	205,400
48	36,450	48,700	58,350	72,950	87,500	109,400	145,850	218,800
49	38,800	51,850	62,050	77,600	93,100	116,400	155,200	232,750
50	41,200	55,050	65,950	82,450	98,950	123,650	164,900	247,300
51	43,750	58,450	70,000	87,500	105,000	131,250	174,950	262,450
52	46,350	61,950	74,200	92,750	111,300	139,100	185,450	278,200
53	49,100	65,600	78,550	98,200	117,800	147,300	196,350	294,550
54	51,900	69,350	83,100	103,850	124,600	155,750	207,700	311,550
55	54,850	73,300	87,800	109,700	131,650	164,600	219,450	329,150
56	57,900	77,350	92,650	115,800	139,000	173,750	231,650	347,450
57	61,050	81,600	97,700	122,150	146,550	183,200	244,250	366,400
58	64,350	85,950	102,950	128,700	154,400	193,000	257,350	386,050
59	67,700	90,500	108,350	135,450	162,550	203,150	270,900	406,350
60	71,250	95,150	113,950	142,450	170,950	213,700	284,900	427,350
61	74,850	100,000	119,750	149,700	179,650	224,550	299,400	449,100
62	78,600	105,000	125,750	157,200	188,600	235,750	314,350	471,550
63	82,450	110,150	131,900	164,900	197,900	247,350	329,800	494,700
64	86,450	115,500	138,300	172,900	207,450	259,350	345,750	518,650
65	90,550	121,000	144,900	181,100	217,350	271,650	362,250	543,350
66	94,800	126,650	151,700	189,600	227,500	284,400	379,200	568,800
67	99,200	132,500	158,700	198,350	238,000	297,550	396,700	595,050
68	103,700	138,500	165,900	207,350	248,850	311,050	414,750	622,100
69	108,350	144,700	173,300	216,650	260,000	325,000	433,300	649,950
70	113,100	151,100	180,950	226,200	271,450	339,300	452,400	678,650
71	118,000	157,700	188,850	236,050	283,250	354,050	472,100	708,150
72	123,100	164,450	196,950	245,150	295,400	369,250	492,300	738,450
73	128,300	171,400	205,250	256,550	307,850	384,850	513,100	769,650
74	133,600	178,500	213,800	267,250	320,700	400,850	534,500	801,750
75	139,100	185,850	222,600	278,250	333,850	417,350	556,450	834,700
76	144,750	193,400	231,600	289,500	347,400	434,250	579,000	868,500
77	150,550	201,100	240,850	301,100	361,300	451,650	602,150	903,250
78	156,500	209,050	250,350	312,950	375,550	469,450	625,950	938,900
79	162,600	217,200	260,150	325,150	390,200	487,750	650,300	975,500
80	168,850	225,550	270,150	337,650	405,200	506,500	675,350	1,013,000

TABLE 78

Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 3,600 Pounds Per Square Inch (Northern White Cedar, Redwood)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)							
	900	1,200	1,440	1,800	2,160	2,700	3,600	5,400
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
20	1,900	2,550	3,050	3,800	4,550	5,700	7,600	11,400
21	2,200	2,950	3,500	4,400	5,300	6,600	8,800	13,200
22	2,550	3,350	4,050	5,050	6,050	7,600	10,100	15,150
23	2,900	3,850	4,600	5,800	6,950	8,650	11,550	17,350
24	3,300	4,400	5,250	6,550	7,900	9,850	13,150	19,700
25	3,700	4,950	5,950	7,400	8,900	11,150	14,850	22,250
26	4,150	5,550	6,700	8,350	10,000	12,500	16,700	25,050
27	4,650	6,250	7,500	9,350	11,200	14,000	18,700	28,050
28	5,200	6,950	8,350	10,400	12,500	15,650	20,850	31,250
29	5,800	7,700	9,250	11,600	13,900	17,350	23,150	34,750
30	6,400	8,550	10,250	12,800	15,400	19,250	25,650	38,450
31	7,050	9,450	11,300	14,150	17,000	21,200	28,300	42,450
32	7,800	10,350	12,450	15,550	18,650	23,350	31,100	46,700
33	8,550	11,400	13,650	17,050	20,500	25,600	34,150	51,200
34	9,350	12,450	14,950	18,650	22,400	28,000	37,350	56,000
35	10,200	13,550	16,300	20,350	24,450	30,550	40,700	61,100
36	11,100	14,750	17,700	22,150	26,600	33,250	44,300	66,450
37	12,050	16,050	19,250	24,050	28,850	36,100	48,100	72,150
38	13,050	17,350	20,850	26,050	31,250	39,100	52,100	78,150
39	14,100	18,800	22,550	28,150	33,800	42,250	56,350	84,500
40	15,200	20,250	24,300	30,400	36,450	45,600	60,800	91,150
41	16,350	21,800	26,200	32,750	39,250	49,100	65,450	98,200
42	17,600	23,450	28,150	35,200	42,200	52,750	70,350	105,550
43	18,900	25,150	30,200	37,750	45,300	56,650	75,500	113,250
44	20,200	26,950	32,350	40,450	48,550	60,650	80,900	121,350
45	21,650	28,850	34,600	43,250	51,900	64,900	86,550	129,800
46	23,100	30,800	37,000	46,200	55,450	69,350	92,450	138,650
47	24,650	32,850	39,450	49,300	59,150	73,950	98,600	147,900
48	26,250	35,000	42,000	52,500	63,000	78,750	105,050	157,550
49	27,950	37,250	44,700	55,850	67,050	83,800	111,750	167,600
50	29,700	39,550	47,500	59,350	71,250	89,050	118,700	178,050
51	31,500	42,000	50,400	63,000	75,600	94,500	126,000	188,950
52	33,400	44,500	53,400	66,750	80,100	100,150	133,550	200,300
53	35,350	47,150	56,550	70,700	84,850	106,050	141,400	212,100
54	37,400	49,850	59,800	74,750	89,700	112,150	149,550	224,300
55	39,500	52,650	63,200	79,000	94,800	118,500	158,000	237,000
56	41,700	55,600	66,700	83,400	100,050	125,100	166,800	250,150
57	43,950	58,600	70,350	87,950	105,500	131,900	175,850	263,800
58	46,300	61,750	74,100	92,650	111,200	138,950	185,300	277,950
59	48,750	65,000	78,000	97,500	117,050	146,300	195,050	292,550
60	51,300	68,400	82,050	102,550	123,100	153,850	205,150	307,700
61	53,900	71,850	86,200	107,800	129,350	161,650	215,550	323,350
62	56,600	75,450	90,550	113,150	135,800	169,750	226,350	339,500
63	59,350	79,150	95,000	118,750	142,500	178,100	237,450	356,200
64	62,250	83,000	99,600	124,500	149,350	186,700	248,950	373,450
65	65,200	86,950	104,300	130,400	156,500	195,600	260,800	391,200
66	68,250	91,000	109,200	136,500	163,800	204,750	273,050	409,550
67	71,400	95,200	114,250	142,800	171,400	214,200	285,650	428,450
68	74,650	99,550	119,450	149,300	179,150	223,950	298,600	447,900
69	78,000	104,000	124,800	156,000	187,200	234,000	312,000	467,950
70	81,450	108,600	130,300	162,850	195,450	244,300	325,750	488,600
71	85,000	113,300	135,950	169,950	203,950	254,950	339,900	509,850
72	88,600	118,150	141,800	177,250	212,700	265,850	354,450	531,700
73	92,350	123,150	147,800	184,700	221,650	277,100	369,450	554,150
74	96,200	128,300	153,950	192,400	230,900	288,600	384,850	577,250
75	100,150	133,550	160,250	200,300	240,400	300,500	400,650	600,950
76	104,200	138,950	166,750	208,450	250,150	312,650	416,900	625,350
77	108,400	144,500	173,400	216,800	260,150	325,150	433,550	650,350
78	112,650	150,200	180,250	225,350	270,400	338,000	450,650	676,000
79	117,050	156,100	187,300	234,100	280,950	351,150	468,250	702,350
80	121,550	162,100	194,500	243,100	291,750	364,700	486,250	729,350

Depreciation of Wood Poles

Order 1261, A, 4 stipulates that wood poles shall be of such material and dimensions that the loading specified in section 125 will not cause the fiber stresses given in Table 20 to be exceeded. The allowable fiber stresses vary with the grade of construction, and even with a stated grade of construction vary according to the situation and according to whether the pole has had previous preservative treatment. When the pole has deteriorated to such an extent that the fiber stress reaches another specified value, the pole must be replaced. The percentage of depreciation varies with the conditions. Table 79 gives the minimum permissible depreciated ground-line circumference for poles which have just met the requirements when installed. Table 82 gives the same information in terms of the permissible reduction in the radius of the cross section of the pole taken at the ground line. Table 80 shows the situations to which the various values in Tables 79 and 82 apply.

TABLE 79

Minimum Depreciated Ground-Line Circumference of Wood Poles

Ground-line circumference when installed (inches)	Minimum allowable depreciated ground-line circumference for ratio of fiber stress when installed to fiber stress when depreciated of—					
	2/3	3/5	5/9	1/2	4/9	2/5
	Inches	Inches	Inches	Inches	Inches	Inches
24	21.0	20.2	19.7	19.0	18.3	17.7
25	21.8	21.1	20.6	19.8	19.1	18.4
26	22.7	21.9	21.5	20.6	19.8	19.2
27	23.6	22.8	22.2	21.4	20.6	19.9
28	24.5	23.6	23.0	22.2	21.4	20.6
29	25.3	24.5	23.8	23.0	22.1	21.4
30	26.2	25.3	24.7	23.8	22.9	22.1
31	27.1	26.1	25.5	24.6	23.7	22.8
32	28.0	27.0	26.3	25.4	24.4	23.6
33	28.8	28.0	27.1	26.2	25.2	24.3
34	29.7	28.7	28.0	27.0	25.9	25.0
35	30.6	29.5	28.8	27.8	26.7	25.8
36	31.4	30.4	29.6	28.6	27.5	26.5
37	32.3	31.2	30.4	29.4	28.2	27.3
38	33.2	32.0	31.2	30.2	29.0	28.0
39	34.1	32.9	32.1	30.9	29.8	28.7
40	34.9	33.7	32.9	31.7	30.5	29.5
41	35.8	34.6	33.7	32.5	31.3	30.2
42	36.7	35.4	34.5	33.3	32.1	31.0
43	37.6	36.3	35.4	34.1	32.8	31.7
44	38.4	37.1	36.2	34.9	33.6	32.4
45	39.3	38.0	37.0	35.7	34.3	33.2
46	40.2	38.8	37.8	36.5	35.1	33.9
47	41.1	39.6	38.6	37.3	35.9	34.6

TABLE 79

Minimum Depreciated Ground-Line Circumference of Wood Poles—Continued

Ground-line circumference when installed (inches)	Minimum allowable depreciated ground-line circumference for ratio of fiber stress when installed to fiber stress when depreciated of—					
48	41.9	40.5	39.5	38.1	36.6	35.4
49	42.8	41.3	40.3	38.9	37.4	36.1
50	43.7	42.4	41.1	39.7	38.2	36.8
51	44.5	43.0	41.9	40.5	38.9	37.6
52	45.4	43.7	42.7	41.3	39.7	38.3
53	46.3	44.7	43.6	42.1	40.4	39.0
54	47.2	45.5	44.4	42.9	41.2	39.8
55	48.0	46.4	45.2	43.7	42.0	40.5
56	48.9	47.2	46.0	44.4	42.7	41.3
57	49.8	48.1	46.9	45.2	43.5	42.0
58	50.7	48.9	47.7	46.0	44.3	42.7
59	51.5	49.8	48.5	46.8	45.0	43.5
60	52.4	50.6	49.3	47.6	45.8	44.2
61	53.3	51.4	50.2	48.4	46.5	44.9
62	54.2	52.3	51.0	49.2	47.3	45.7
63	55.0	53.1	51.8	50.0	48.1	46.4
64	55.9	54.0	52.6	50.8	48.8	47.2
65	56.8	54.8	53.4	51.6	49.6	47.9
66	57.7	55.7	54.3	52.4	50.4	48.6
67	58.5	56.5	55.1	53.2	51.1	49.4
68	59.4	57.4	55.9	54.0	51.9	50.1
69	60.3	58.2	56.7	54.8	52.6	50.8
70	61.2	59.0	57.5	55.6	53.4	51.6
71	62.0	59.9	58.4	56.4	54.2	52.3
72	62.9	60.7	59.2	57.1	54.9	53.0
73	63.8	61.6	60.0	57.9	55.7	53.8
74	64.6	62.4	60.8	58.7	56.5	54.5
75	65.5	63.2	61.7	59.5	57.2	55.3

TABLE 80

Allowable Depreciation of Wood Poles Under Vertical and Transverse Loading for Various Situations

(This table locates the situations to which the columns of Tables 79 and 82 apply)

	Ratio of Maximum fiber stress when installed to maximum fiber stress when depreciated for—	
	Treated poles	Untreated poles
At crossings.		
In lines of one grade of construction throughout—		
Grade A	2/3	2/3
Grade B	2/3	2/3
Grade C	7/8	2/3
	1/2	1/2
In isolated sections of higher grade of construction in lines of a lower grade of construction—		
Grade A	2/3	1/2
Grade B	2/3	4/9
Grade C	7/8	2/5
	1/2	
Elsewhere than at crossings.		
Grade A	2/3	5/9
Grade B	3/5	1/2
Grade C	2/3	1/2

When pole timbers are used that have ultimate strengths different from those listed, the dimensions of the poles of grades A, B, or C to withstand the vertical and transverse loads assumed in the Code, section 125, may be determined by application of the ratios of ultimate fiber stress of the wood to allowable fiber stress as installed under the various conditions stipulated in Table 81.

TABLE 81

Ratio of Ultimate Fiber Stresses of Wood Poles to Allowable Fiber Stresses Under Vertical and Transverse Loading, Grade A, B, or C

Situation and grade	When installed		At replacement
	Treated poles	Untreated poles	Treated or untreated poles
At crossings.			
Poles in lines of one grade of construction throughout—			
Grade A	3	3	2
Grade B	2	2	1⅓
Grade C	1⅓	1⅓	⅔
Poles in isolated sections of higher grade of construction in lines of a lower grade of construction—			
Grade A	3	4	2
Grade B	2	3	1⅓
Grade C	1⅓	1⅔	⅔
Elsewhere than at crossings.			
Grade A	2½	3	1⅔
Grade B	1⅔	2	1
Grade C	1	1⅓	⅔

TABLE 82

Maximum Radial Depreciation of Wood Poles

Ground-line circumference when installed (inches)	Maximum allowable radial depreciation for ratio of fiber stress when installed to fiber stress when depreciated of—					
	⅔	3/5	5/9	½	4/9	2/5
	Inches	Inches	Inches	Inches	Inches	Inches
24	0.48	0.60	0.68	0.79	0.90	1.01
25	.50	.62	.71	.82	.94	1.05
26	.52	.66	.72	.85	.98	1.09
27	.54	.67	.76	.89	1.02	1.13
28	.56	.70	.79	.92	1.06	1.17
29	.58	.72	.82	.95	1.09	1.21
30	.60	.75	.85	.99	1.13	1.26
31	.62	.77	.88	1.02	1.17	1.30
32	.64	.80	.91	1.05	1.21	1.34
33	.66	.82	.93	1.08	1.24	1.38
34	.68	.85	.96	1.12	1.28	1.42
35	.70	.87	.99	1.15	1.32	1.47
36	.72	.90	1.02	1.18	1.36	1.51
37	.75	.92	1.05	1.22	1.40	1.55
38	.76	.95	1.07	1.25	1.43	1.59
39	.78	.97	1.10	1.28	1.47	1.63
40	.80	1.00	1.13	1.31	1.51	1.68
41	.82	1.02	1.16	1.35	1.55	1.72
42	.85	1.05	1.19	1.38	1.58	1.76
43	.86	1.07	1.22	1.41	1.62	1.80
44	.88	1.10	1.25	1.44	1.66	1.84
45	.90	1.12	1.27	1.48	1.70	1.88
46	.93	1.15	1.30	1.51	1.74	1.93
47	.95	1.17	1.33	1.54	1.77	1.97
48	.97	1.20	1.36	1.58	1.81	2.01
49	.99	1.22	1.39	1.61	1.85	2.05
50	1.01	1.25	1.42	1.64	1.89	2.09
51	1.03	1.27	1.44	1.67	1.92	2.14
52	1.05	1.30	1.47	1.71	1.96	2.18
53	1.07	1.32	1.50	1.74	2.00	2.22
54	1.09	1.35	1.53	1.77	2.03	2.26
55	1.11	1.37	1.56	1.81	2.07	2.30
56	1.13	1.40	1.59	1.84	2.11	2.35
57	1.15	1.42	1.61	1.87	2.15	2.39
58	1.17	1.45	1.64	1.90	2.19	2.43
59	1.19	1.47	1.67	1.94	2.23	2.47
60	1.21	1.50	1.70	1.96	2.26	2.51
61	1.23	1.52	1.73	2.00	2.30	2.55
62	1.25	1.55	1.76	2.03	2.34	2.60
63	1.28	1.57	1.78	2.07	2.37	2.64
64	1.29	1.60	1.81	2.10	2.41	2.68
65	1.31	1.62	1.84	2.14	2.45	2.72
66	1.33	1.65	1.87	2.17	2.49	2.76
67	1.35	1.67	1.90	2.20	2.53	2.81
68	1.37	1.70	1.93	2.23	2.56	2.85
69	1.39	1.72	1.95	2.26	2.60	2.89
70	1.41	1.74	1.98	2.30	2.64	2.93
71	1.43	1.77	2.01	2.33	2.68	2.97
72	1.45	1.79	2.04	2.36	2.71	3.02
73	1.47	1.82	2.07	2.40	2.75	3.06
74	1.49	1.84	2.09	2.43	2.79	3.10
75	1.51	1.87	2.12	2.46	2.83	3.14

Transverse Loads on Poles

Transverse and vertical loads on poles of grades A, B, C, D, or E are assumed to act simultaneously. The fiber stresses caused by the transverse wind forces on poles and wires must therefore be added to the fiber stresses caused by the weights of the loaded conductors supported when determining the safety of the pole.

Transverse loads on a line result in a bending moment on unguyed poles. The bending moment at the ground line is determined by multiplying the transverse force resulting from the assumed loads of section 125, by the height of the transverse force.

The transverse force acting on the conductors in lines of grades A, B, C, D, and E for any given loading district may be found by use of the values of transverse loads on conductors per foot of length given in Table 73. The transverse force in pounds contributed by each conductor is obtained by multiplying the transverse force per foot by the span length in feet or by one-half the sum of the adjacent spans. The moment in pound-feet due to the transverse force on each conductor, acting at the ground line of the pole, is found by multiplying this force by the height in feet at which it is applied. The total moment in pound-feet acting at the ground line of the pole is the sum of the moments resulting from conductors or messengers contributing to the transverse load under the loading assumptions, and the moment resulting from the transverse wind pressure on the pole itself. The moment in pound-feet resulting from the transverse wind force on the pole itself, assuming a pole of circular cross section tapering uniformly, may be obtained from Table 83, or from the following formulas:

For heavy and medium loading, $M = [4(D + 2d)h^2]/3$ pound-feet.

D = diameter at ground line in feet.
d = diameter at top in feet.
h = height of pole in feet.

TABLE 83

Moments Due to Wind Pressure on Poles

HEAVY LOADING

T = Top circumference in inches G = Ground-line circumference in inches	Moment due to wind pressure on poles of various heights above ground							
	15 feet	17 feet	20 feet	24.5 feet	29 feet	34 feet	38.5 feet	43 feet
2T+G=K	For immediate value of K interpolate by using these differences per unit							
	8	10	14	21	30	41	52	65
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
52	414	532	736					
56	446	572	792	1,189	1,666			
60	477	613	849	1,274	1,785	2,453	3,145	3,924
64	509	654	905	1,359	1,904	2,617	3,355	4,185
68	541	695	962	1,444	2,023	2,780	3,565	4,447
72	573	736	1,019	1,529	2,142	2,944	3,775	4,708
76	605	777	1,075	1,613	2,261	3,107	3,984	4,970
80	637	818	1,132	1,698	2,380	3,271	4,194	5,232
84	668	859	1,188	1,783	2,499	3,434	4,404	5,493
88	700	899	1,245	1,868	2,617	3,598	4,613	5,755
92	732	940	1,302	1,953	2,736	3,761	4,823	6,016
96	764	981	1,358	2,038	2,855	3,925	5,033	6,278
100	796	1,022	1,415	2,123	2,974	4,089	5,242	6,539
104	828	1,063	1,471	2,208	3,093	4,252	5,452	6,801
108	859	1,104	1,528	2,293	3,212	4,416	5,662	7,063
112	891	1,145	1,584	2,378	3,331	4,579	5,871	7,324
116		1,186	1,641	2,463	3,450	4,743	6,081	7,586
120		1,227	1,698	2,548	3,569	4,906	6,291	7,847
124			1,754	2,632	3,688	5,070	6,501	8,109
128				2,717	3,807	5,233	6,710	8,371
132				2,802	3,926	5,397	6,920	8,632
136					4,045	5,560	7,130	8,894
140					4,164	5,724	7,339	9,155
144						5,887	7,549	9,417
148						6,051	7,759	9,678
152						6,215	7,968	9,940
156						6,378	8,178	10,200
160						6,542	8,388	10,460
164						6,705	8,598	10,720
168						6,869	8,807	10,990

TABLE 83 (Continued)

Moments Due to Wind Pressure on Poles—Continued

HEAVY LOADING—Continued

T = Top circumference in inches G = Ground-line circumference in inches	Moment due to wind pressure on poles of various heights above ground					
	48 feet	52.5 feet	57 feet	62 feet	66.5 feet	71 feet
	For immediate values of K interpolate by using these differences per unit					
2T+G=K	82	98	115	136	156	178
	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.	Lb.-ft.
68	5,541					
72	5,867	7,019				
76	6,193	7,409				
80	6,519	7,799	9,193	10,880		
84	6,845	8,189	9,652	11,420		
88	7,171	8,578	10,110	11,960	13,760	15,690
92	7,497	8,968	10,570	12,510	14,390	16,400
96	7,823	9,358	11,030	13,050	15,010	17,120
100	8,149	9,748	11,490	13,600	15,640	17,830
104	8,475	10,140	11,950	14,140	16,270	18,540
108	8,801	10,530	12,410	14,680	16,890	19,260
112	9,127	10,920	12,870	15,230	17,520	19,970
116	9,453	11,310	13,330	15,770	18,140	20,680
120	9,778	11,700	13,790	16,310	18,770	21,390
124	10,100	12,090	14,250	16,860	19,390	22,110
128	10,430	12,480	14,710	17,400	20,020	22,820
132	10,760	12,870	15,170	17,950	20,650	23,530
136	11,080	13,260	15,630	18,490	21,270	24,250
140	11,410	13,650	16,090	19,030	21,900	24,960
144	11,730	14,040	16,550	19,580	22,520	25,670
148	12,060	14,430	17,010	20,120	23,150	26,390
152	12,390	14,820	17,470	20,660	23,770	27,100
156	12,710	15,210	17,930	21,210	24,400	27,810
160	13,040	15,600	18,390	21,750	25,020	28,530
164	13,360	15,990	18,850	22,300	25,650	29,240
168	13,690	16,380	19,300	22,840	26,280	29,950
172	14,020	16,770	19,760	23,380	26,900	30,670
176	14,340	17,160	20,220	23,930	27,530	31,380

The values of moments due to wind pressure given in Table 83 are based upon a number K which is found by adding the ground-line circumference to twice the value of the pole-top circumference in inches. By combining the two circumferences in this way, the table is simplified and greatly reduced in extent. Having found K, the value for the moment due to wind pressure is given in the same line as the value for K and in the column which is headed by the height above ground of the given pole. For intermediate values of K the proper value can be found by interpolation, using the differences given at the head of each column. The tabulated values give more significant figures than would otherwise be warranted, in order to avoid inaccuracies in interpolation.

When computing the total moment to be resisted by a pole under heavy or medium loading, supporting 10 wires or less, not including cables carried by messengers, it is found by adding together the moments due to each conductor and each cable and messenger and that due to the pole itself.

When the pole is carrying more than 10 wires not including cables supported by messengers, and the pin spacing does not exceed 15 inches, the moment due to the wires is calculated for two-thirds of the total number, but for not less than 10 wires. The moment due to the wires thus calculated is added to that due to the cables and messengers and the pole itself to find the total moment to be resisted by the pole under heavy or medium loading.

When a trolley contact conductor is supported from a pole also carrying other wires or cables, the transverse moment resulting from the trolley contact conductors is added as part of the total moment to be resisted by the pole.

At angles in a line an unbalanced side pull is imposed on the corner pole due to change in direction of the conductors. The total moment to be resisted in this case is that due to a transverse load equal to the resultant of all conductor and messenger tensions under loaded conditions.

When considering the safety of poles of grades A, B, C, D, or E, the fiber stress caused by the moments of the transverse wind forces on poles and conductors must be added to the fiber stresses caused by the vertical loads carried by the pole. The sum of these fiber stresses should be less than the maximum allowable fiber stress. Table 20 lists maximum allowable fiber stresses for certain timbers, and Table 81 gives the factors of safety for different situations of grade A, B, or C construction.

Vertical Loads on Poles

The vertical force acting on conductors in lines of grades A, B, C, D, or E for any loading district may be found by use of the values of the weight of loaded conductors per foot of length given in Table 72. The vertical force in pounds for each conductor is obtained by multiplying the loaded weight per foot by the span in feet or by one-half the sum of the adjacent spans. The vertical force supported by the pole is the sum of conductor loads. The weight of the pole itself is neglected.

Longitudinal Loads on Poles

Longitudinal loads on a pole result from the pulls of conductors. The conductor pulls are determined under loaded conditions in conformity with the assumed loads of section 125.

The bending moment in pound-feet at the ground line is determined by multiplying the pull in pounds of each conductor contributing to the longitudinal load under the loading assumptions by its height in feet. If the conductors are strung to the minimum permissible sags of grades A, B, or C, the tensions will be 50 per cent of the breaking tension for grades A and B and 60 per cent for grade C. The breaking tensions of various types of line conductors may be found in the tables of mechanical data for wires and cables of Appendix C. If the conductors are strung to sags differing from those mentioned above, the tensions under loaded conditions may be obtained by calculation.

The longitudinal pull of communication conductors may always be assumed to be one-half their breaking tension regardless of the sag (see Appendix C, for tables of breaking strength), except in grade A or B joint lines, where this is applicable only if conductors are smaller than No. 8 Stl. W. G. steel or No. 6 A. W. G. copper.

At dead ends and angles the longitudinal moment is computed by adding together the moments of all unbalanced conductor and cable pulls. In these situations the resisting moment of the pole is based on the allowable maximum fiber stresses for transverse loads in the same loading district and of the same grade of construction. In all other situations the resisting moment of the pole is based on the allowable fiber stresses for longitudinal loads.

When computing the longitudinal moment where a change of grade occurs in a line, the longitudinal loading upon poles at the ends of sections required to be grade A or B construction in lines of a lower grade is taken as an unbalanced pull in the direction of the higher-grade section equal to the total pull in one direction of all conductors and cables supported. This longitudinal load may be mitigated for higher-grade sections having no span exceeding 500 feet in length where the total pull in the direction of the higher grade exceeds 30,000 pounds. In this case the longitudinal force is modified to 30,000 pounds plus one-fourth the excess above 30,000, with a maximum of 50,000 pounds.

When computing the longitudinal moment where a line is built throughout its length, or between dead-ended points, of grade A or B construction, although not so required, the longitudinal force upon poles at crossings, at ends of sections of joint use, and at ends of conflicts required to be of grade A or B construction, respectively, is taken as an unbalanced pull in the direction of the crossing, conflict or joint-use section equal to the pull of one-third of the total number of conductors carried, not including overhead ground wires. The one-third selected for computation must be a whole number or the next larger whole number and must be selected to produce the maximum stress in the pole.

Allowable Number of Wires on a Given Pole With and Without Side Guys

Table 84 gives the allowable number of No. 4 covered, solid, copper wires to be carried by a 35-foot pole of any wood having an ultimate fiber stress of 5,000 pounds per square inch. This number varies with the grade of construction and with the loading district. In this table it is assumed (1) that poles are set 6 feet in the ground; (2) that the cross arms are 2 feet apart; (3) that 6-pin cross arms are used up to 30 wires, and 8-pin arms for 31 or more wires; (4) that the placing of wires is begun at the top arm (wires 6 inches below the top of poles) and continues to lower cross arms after all wire positions are filled; (5) that the clearance of wires above ground is never less than 18 feet; (6) that the taper of poles amounts to 2 inches of circumference per 5 feet of length. Strengths are computed at the ground line. The values given apply to untreated poles in situations of conflict or joint use, or to poles either treated or untreated at crossings in a line of uniform construction. The values also hold for treated poles used at crossings where the construction differs from the remainder of the line.

Tables 85 and 86 are based upon the assumption (1) that the guys carry their loads with a factor of safety of 2; (2) that they are installed with a lead of 1 to 3; (3) that they are attached at the center of the load, thus making it unnecessary to take into account the height of the pole. The wind pressure on the pole itself has not been taken into account in these tables. This addition to the load is equivalent to that due to one or more wires, depending upon the size and height of the pole and length of span and deduction should be made in each case.

TABLE 84

Allowable Number of No. 4 Solid Copper T. B. W. P. Wires to be Carried by Untreated 35-Foot Poles of Woods Classed as of 5,000 Pounds per Square Inch Ultimate Fiber Stress (Pine, Cypress, etc.)

(For grades A, B, and C (except at crossings in isolated sections of higher grade) in heavy loading districts)

Grade and loading	Maximum stress in pole	Span	Allowable number of wires for ground-line circumference of—								
			32 in.	34 in.	36 in.	38 in.	40 in.	42 in.	44 in.	46 in.	48 in.
	Lbs./sq. in.	Feet									
A. H.	1,670	100	a4	5	6	8	9	11	14	16	18
		125	a3	4	5	6	7	9	10	12	14
		150	a3	3	4	5	6	7	9	10	11
		200	a2	2	3	4	4	5	6	7	8
B. H.	2,500	100	7	9	11	13	16	18	22	26	31
		125	6	7	8	10	12	14	17	20	23
		150	5	6	7	8	10	12	14	16	19
		200	3	4	5	6	7	9	10	12	14
C. H.	3,750	100	11	14	17	21	26	30	35	b40	b40
		125	9	11	13	16	20	23	28	32	37
		150	7	9	11	13	16	19	22	27	29
		200	5	7	8	10	11	14	16	19	23

a For grade A in heavy and medium loading districts, 35-foot poles cannot be used with so small a ground line circumference, since pole top would be less than 7 inches. (See Order 1261, A. 4. (g).)

b These numbers of wires will fill all available pole space when carried on 8-pin cross arms, but will not use up the available strength of the pole.

TABLE 85

Allowable Number of No. 4 Solid Copper T. B. W. P. Wires to be Carried on Poles Supported by Side Guys of Various Strengths under Various Grades of Construction (A, B, or C) Heavy Loading

Grade and loading	Span	Number of wires to be carried by poles supported by the following numbers and strengths of guys						
		One 4,000 pound	One 6,000 pound	One 10,000 pound	One 16,000 pound	Two 10,000 pound	One 10,000 pound one 16,000 pound	Two 16,000 pound
	Feet							
A. H. and B. H.	75	9	13	22	36	45	59	73
	100	6	10	17	27	34	44	55
	125	5	8	13	22	27	35	44
	150	4	6	11	18	22	29	36
	200	3	5	8	13	17	22	27
C. H.	75	13	20	34	55	68	89	110
	100	10	15	25	41	51	67	82
	125	8	12	20	33	41	53	66
	150	6	10	17	27	34	44	55
	200	5	7	12	20	25	33	41

TABLE 86

Allowable Number of No. 8 B. W. G. Bare Iron Wires to be Carried on Poles Supported by Side Guys of Various Strengths under Various Grades of Construction (D or E) and Heavy Loading

Grade and loading	Span	One 4,000 pound	One 6,000 pound	One 10,000 pound	One 16,000 pound	Two 10,000 pound	One 10,000 pound, one 16,000 pound	Two 16,000 pound
D. H.	75	10	16	27	43	54	70	86
	100	8	12	20	32	40	53	65
	125	6	9	17	26	32	42	52
	150	5	8	13	21	29	35	43
E. H.	75	16	24	40	65	81	------	------
	100	12	18	30	48	61	79	97
	125	9	14	24	39	48	63	78
	150	8	12	20	32	40	53	65

Note.—The blank spaces in the above tables indicate that more than 100 wires can be carried by the size and number of guys in question under the indicated conditions of hazard, loading, and span length without exceeding one-half of the ultimate strength of the guys. Where the number of wires carried by a pole exceeds 80 it is good practice to install some of them in cable.

Depth of Setting of Poles

The values given in Table 87 are those recommended as the depth to which poles should be set under ordinary straight-line conditions in firm soil or rock. On corners or angles, or heavy dead ends, these values should be increased by at least 6 inches. (See Order 1262, B.)

TABLE 87

Recommended Depth of Setting of Poles—Order 1262, B

Length of pole in feet	Setting in soil	Setting in rock
	Feet	Feet
20	5.0	3.0
25	5.0	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.0	5.0
60	7.5	5.0
65	8.0	6.0
70	8.0	6.0
75	8.5	6.0
80	9.0	6.5

PART 3

ELECTRICAL UTILIZATION EQUIPMENT

SECTION 130. SCOPE OF ORDERS

In Part 3 the National Electrical Code has 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 of the order number and omitting the decimal point.

Order 1300. Application of Orders.

A. *Equipment Accessible to Other Than Qualified Persons.*

1. Equipment of less than 600 volts.

The following orders, Sections 130–139, inclusive apply to all electrical utilization equipment, operating at voltages below 600 volts, except where other voltage limitations are given, where accessible to other than qualified electrical operators, as in mills, factories, mercantile establishments, hotels, theaters, and other public buildings, apartment houses, residences, etc.

Exception: Communication equipment connected to communication lines, and radio apparatus is exempted, except from Section 136.0 and Section 133.7.

Note: (a) In all wiring special attention should be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of conductors, and securing and attaching of fittings, are especially conducive to security and efficiency, and are strongly advised.

(b) In laying out an installation, except for constant-current systems, every reasonable effort should be made to secure distribution centers located in easily accessible places, at which points fuses, circuit breakers, and switches controlling the several branch circuits can be grouped for convenience and safety of operation. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

(c) The use of wire-ways for rendering concealed wiring permanently accessible is recommended; and this method of accessible concealed construction is advised for general use.

Architects are urged when drawing plans and specifications to make provision for the channeling and pocketing of buildings for electric light or power wires and also for telephones, district messenger and other signalling system wiring.

In making layouts architects should also pay attention to the need for adequate space and proper location for electrical equipment including service equipment. See Order 1302.01 and Section 130.4.

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

2. Equipment of more than 600 volts. Equipment and conductors of more than 600 volts, where accessible to other than qualified electrical operators, shall (in addition to complying with the rules of part 3 for conductors of more than 300 volts) comply also with the rules for electrical supply stations, part 1, where such rules require more than the rules of part 3. Current-carrying parts shall be either incased in permanently grounded metal cases or conduits, or otherwise suitably guarded to prevent access (or too close approach) to such current-carrying parts by any but qualified persons.

b. *Equipment Accessible to Qualified Persons Only.*

Electrical utilization equipment, however, as well as generating equipment, if inclosed in a separate room or similar enclosed area which is in charge of a qualified person and which is accessible only to such persons, may be installed in conformity with the orders applying to Electrical Supply Stations (Part 1) and in that case does not come under these orders. (See also Order 1101, Section 110, Part 1.)

SECTION 130.1. GENERAL PROTECTIVE ARRANGEMENTS

Order 1301. Guarding or Isolating Live Parts.

a. *Inclosure or elevation.* All bare, ungrounded live parts of electric utilization equipment, such as bus bars, conductors, and terminals, operating at more than 100 volts to ground, shall be protected by one of the following means:

1. Inclosure, which gives access to live parts only through opening a door or cover.

2. Guarding, as by railing, screen, or barriers which remove the liability of contact or approach.

3. Isolation, by placing at least 8 feet above the floor line, or by removing beyond ready accessibility.

Note: Inclosures may consist of suitable casings or suitable insulating coverings. The continuous insulating covering of conductors should be depended upon only when the circuit is grounded in accordance with section 103 or is less than 300 volts to ground and entirely unexposed to leakage or induction from higher-voltage circuits, and where, in addition, it is impracticable to install more suitable guards. It should be depended upon then only when the covering is not exposed to liability of mechanical injury and is very substantial, thoroughly dry, and contains no non-insulating flame-proofing compound or oil-soaked rubber. It is recommended that in addition to the protection afforded by such coverings the insulating mats or platforms called for in paragraph (b) be used.

Where covers, casings, or barriers must at any time be removed from the current-carrying parts which they guard while these parts are alive, the covers, casings, or barriers should be of insulating material or so arranged that they can not readily be brought in contact with the live parts.

b. *Where mats and platforms are used.* Where current-carrying parts of more than 150 volts to ground must necessarily be exposed (unguarded) within 8 feet from the floor, all surrounding conducting floors and other conducting surfaces within reach shall be covered with suitable insulating platforms, mats, or other insulating devices.

Note: Mats may be of wood, held together by wood pins, or of cork matting, linoleum, or rubber. The material and construction should be suitable for the voltage concerned and for the prevailing conditions. If subject to moisture or to accumulations of conducting dust, flyings, or chips, mats should present surfaces minimizing the hazards from these sources.

c. *Conductors.* (For wires in Elevator Shafts see Elevator Code Order 420.)

1. All conductors, not included in (2) and (3) below, shall be guarded by inclosure in rigid or flexible conduit, armored cable, surface metal raceways or other approved raceways, (See also Section 130.5) when brought closer to floor or platform than 8 feet, or when exposed to mechanical injury above that level.

Exception: Trolley conductors, lightning arrester ground conductors, pendants and portable cords are exempt from this order.

2. All conductors in schools, theaters, assembly halls, hotels, hospitals, public garages, as well as apartments and office buildings of fireproof construction, shall be guarded by inclosure in rigid or flexible conduit, armored cable, surface metal raceways or other approved raceways. (See also Section 130.5)

Exception: 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.

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) A public garage is defined by the Wisconsin State Building Code to include every building which accommodates more than two motor-driven vehicles.

(3) These requirements also apply to permanent wiring for radio and public address loud speakers.

3. 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. (See also Order 1301–a)

d. *Separation and Barriers.*

Bare parts at different potentials shall be effectively separated. Such parts in circuits of large capacity or which are operated at more than 300 volts shall, unless provided with the inclosure or other guard specified in (a) above, be provided with suitable barriers, if otherwise they would be liable to be short-circuited by tools or other conducting objects.

SECTION 130.2. GENERAL

Order 1302.01 Working Space About Electrical Equipment.

a. *Adequate Spaces.* Suitable working space shall be provided and maintained about all electric utilization equipment.

b. *Dimensions.* The horizontal dimension of the working space in front of live parts shall not be less than:

(1) For parts on one side of more than 150 volts to ground and no live or grounded parts on the other side of the working space, 2.5 feet.

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

(3) For parts on one side of less than 150 volts to ground and no live or grounded parts on the other, 1.5 feet.

(4) For parts on one side of less than 150 volts to ground and live or grounded parts on the other, 2.5 feet.

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

d. *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 (b) and may be used in lieu thereof.

Order 1302.02. Identification of Equipment.

a. *Safety by identification.* All electric utilization equipment shall be suitably identified when added safety can be obtained thereby.

Note: The identification may be by location, color, number, nameplate, label, design, or other means.

b. *Voltage and use.* The voltage and intended use shall be shown wherever it will reduce the hazard or decrease the liability of error in operation.

Order 1302.03. Wire Terminals, Splices and Joints.

a. Terminal parts by which wire connections are made shall insure thoroughly good connections even under hard usage. For wires larger than No. 8, solder lugs or approved solderless connectors shall be provided. Parts to which wires of No. 8, or smaller size, are to be connected, shall securely grip the conductors. Heavy clamps or screws with terminal plates having upturned lugs, or solderless connectors, may be used.

Note: Lugs or clamps are not required when leads are provided as part of the device.

b. Wires shall be so spliced or joined as to be mechanically and electrically secure without solder. The joints shall then be soldered with a fusible metal or alloy unless made with a splicing device and shall be covered with an insulation equal to that on the wires.

Note: Joints at outlets shall be soldered when wires are installed.

c. Stranded conductors, other than those of flexible cords, shall be soldered together at their ends or shall be made solid by some other approved means before they are fastented under clamps or binding screws.

d. Ends and joints of insulated conductors, unless otherwise adequately guarded, shall have equal insulating covering with other portions of the conductor, and this covering shall be securely held in place.

Order 1302.04. Railway Systems.

a. Lighting and power from railway wires shall not be permitted under any pretense from a system to which are connected trolley wires with a ground return, except in electric railway cars, electric car houses, power houses, passenger and freight stations connected with the operation of electric railways.

b. In car houses and similar locations where service at low voltage is not available and where necessary to use low voltage pendent or portable lamps or other devices in series with lamps on trolley circuits, the devices should be used only with great caution and be placed preferably on the grounded side of the circuit concerned.

Order 1302.05. Approved Materials.

a. This code shall be understood to treat only of approved materials, devices, fittings, appliances, machinery, apparatus and methods.

b. Electric utilization equipment shall be installed and maintained in conformity with these safety orders. Persons in charge of equipment shall have periodic inspections of equipment and wiring made, and similar inspections shall be made by the supervising governmental authority.

Order 1302.06. General Plan of Investigations.

a. Materials, devices, fittings, apparatus and appliances designed for use under this code shall be judged chiefly with reference to the following five considerations which also determine the classification by types, sizes, voltages, current capacities and specific uses:

1. Suitability for installation and use in conformity with the requirements of this code.
2. Mechanical strength and durability, including, for appliances designed to inclose and protect other equipment, the adequacy of the protection thus provided.
3. Electrical insulation.
4. Heating effects under normal conditions of use and also under abnormal conditions liable to arise in service.
5. Arcing effects.

b. A base on which live parts are mounted shall be of insulating material and of a design such that, considering the material used, the base will withstand the most severe conditions liable to arise in service. Holes for supporting screws shall be so located or countersunk that there will be at least ½ inch, measured over the surface, between the screw head or washer and the nearest live metal part, and in all cases, where between parts of opposite polarity, the screw head or washer shall be countersunk. Holes for supporting screws in link fuse cutout bases shall be kept out-

side the area included by the outside edges of the fuse terminals. Nuts or screw heads on the under side of a base shall be countersunk and sealed with a waterproof compound.

c. The set-screw form of contact shall not be used unless designed to insure a thoroughly good connection between the conductor and the terminal parts without damaging the conductor.

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

e. 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 i and j of this order for polarized receptacles for attachment plugs and polarized attachment plug caps.

f. 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.

g. The terminals of portable devices and appliances need not be marked for identification.

h. Devices, to the terminals of which only one side of the line is connected, need not have terminals marked for identification.

i. 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. 2-wire polarized receptacles for attachment plugs and polarized attachment plug caps shall have the terminal intended for connection to the grounded wire marked for identification.

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

k. 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 plug fuse receptacles.

l. 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.

m. In the case of screw-shell devices with attached leads the wire 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.

n. The maker's name, trademark or other identification symbol shall be placed on fittings and materials. Other markings shall be provided giving voltage, current, wattage or other appropriate ratings as are prescribed elsewhere in this code.

Order 1302.07. Mounting Requirements.

a. Electrical apparatus and equipment shall be firmly secured to surfaces upon which it is mounted. Wooden plugs driven into holes in masonry shall not be depended upon for such security.

SECTION 130.3. OUTSIDE SUPPLY CONDUCTORS

Order 1303.01. General.

For services, see Orders 1304.02, 1304.03 of Section 130.4.
For festoon lighting, also see Sections 131.4 and 133.6.
For sign and outline lighting, see Section 133.8.
For wiring and lamps on series circuits of constant-current systems, see Order 1350.01 of Section 135.0.

a. All wiring on exterior of building walls shall comply with the requirements for services in Order 1304.03 and for circuits exceeding 600 volts shall be in rigid conduit or in cable approved for the purpose.

b. Runs of conduit and of electrical metallic tubing on the exterior of buildings shall be waterproof and suitably drained and in other respects shall comply with the requirements of Orders 1305.03 and 1305.08, respectively.

c. Overhead service wires and cables shall be as high above ground at the point of attachment to a building as the height and form of the building and existing local conditions permit, but shall in no case be less than 10 feet

and need not be greater than 18 feet unless in the judgment of the inspection department a greater height is required in a particular case to secure proper clearance from other wires or obstructions.

Order 1303.02. Joint Lines.

See Part 2.

Order 1303.03. Clearances.

See Part 2.

Order 1303.04. Grounding Cable Sheaths.

See Part 2 and Section 103.

Order 1303.05. Trolley Wires in Private Plants.

a. Trolley wires shall be doubly insulated from the ground, wooden poles being considered as one insulation.

b. Trolley wires and feeders shall be provided with switches which will either disconnect them from the power station, or will so sectionalize them that they may be rendered dead in case of fire along the route.

Order 1303.06. Outside Festoon Lighting.

a. Supply shall be taken only from such points on the wiring system as will permit correct fusing. Conductors shall be protected by fuses not larger than the values given in Column C of Table I, Order 1306.12.

b. Conductors of festoon streamers shall have an approved rubber covering. When sockets of the medium or the mogul sizes are used, the conductors, except for approved Christmas-tree and other decorative lighting outfits, shall be not smaller than No. 14, and when the span of any string of such sockets exceeds 40 feet, the string shall be supported by a suitable messenger wire substantially fastened at each end. When sockets of the intermediate or smaller sizes are used, the conductors, except for approved Christmas-tree and other decorative lighting outfits, shall be not smaller than No. 18. Strings of such intermediate or smaller sockets shall be supported either by messenger wires or by other approved means.

c. Festoon lighting strings or messengers shall not be attached to any fire escape or downspout. They shall be supported by secure attachments to buildings, poles or other adequate supports by means of approved strain insulators.

d. Sockets and receptacles shall be of approved moulded composition, weatherproof type, and when they are attached as pendants shall have the connections to the circuit wires

staggered. All joints shall be made mechanically secure, soldered, covered with both rubber and friction tape, and painted with an insulating paint.

SECTION 130.4. SERVICES AND SERVICE EQUIPMENT

(Not over 600 volts)

For Services and Service Equipment for more than 600 volts see Section 135.0. For other outside and entrance conductors see Sections 130.3, 130.5, 133.7 and 133.8.

Order 1304.01. General.

a. No overhead service, no underground service, and no service from an isolated plant shall supply one building through another, except when such buildings are under single occupancy or management. Conductors in conduit or duct placed under 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.

b. Each building shall be supplied with only one service drop except where, because of voltage regulation, consumer classification, or regulatory orders, additional drops are necessary.

c. If supplied by more than one service drop or one set of underground service conductors at the same side of a building, the service equipments shall be grouped (except for fire-pump service, which may be isolated, and also except in the case of a multiple-occupancy building having no available place that is accessible to all of the occupants) and the type of service separately indicated.

d. 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 taps may be made from one continuous set of service entrance conductors.

Note: Switches or other control equipment must be plainly marked as to type of service, voltage, etc.

Order 1304.02. From Main to Building, Overhead.

a. Approved weatherproof or approved rubber covering shall be employed on single conductors, and approved rubber insulation between conductors on multiple-conductor cables, used as service drops. Wires shall not be smaller than No. 10 if of soft copper, or smaller than No. 12 if of medium or hard-drawn copper.

b. Wires or cables shall not approach nearer than 8 feet to buildings over which they pass, and, if attached to roofs thereof, shall be supported on substantial structures.

Note: It is recommended that wires passing over a building be supported on structures which are independent of the building.

Exception: Service drops operating at less than 300 volts need not be more than 3 feet above building roofs which cannot readily be walked on.

c. When service conductors from overhead supply wires are carried underground, the portion of the wires underground and running up the pole to a point at least eight feet above the ground shall be suitably protected from mechanical injury and shall be protected from moisture by a covering of lead or other means approved for the purpose.

d. Multiple-conductor cables used for service drops shall, at the point of attachment to the building, be kept at least six inches from adjacent woodwork and at least 12 inches from overhanging projections of combustible material, unless fittings approved for the purpose are used.

Order 1304.03. On Exterior of Building, Overhead.

a. Wires or cables which are liable to contact with awnings, swinging signs, shutters or other movable objects, shall be inclosed in approved conduit or electrical metallic tubing. All such systems on exteriors of buildings shall be made raintight.

b. Open wires shall not be within 8 feet from the ground, shall not be readily accessible and shall not be subject to mechanical disturbance. If exposed to the weather, they shall be supported on approved insulators, racks, brackets, or other supports approved for the purpose. Such supports shall be placed at intervals not exceeding 9 feet and shall separate the wires at least 6 inches from each other and at least two inches from the surface wired over; provided, however, that supports may be placed at intervals not exceeding 15 feet if they hold the wires at least 12 inches apart. Open wires if not exposed to the weather, may be supported on glass or porcelain knobs placed at intervals not exceeding 4½ feet and maintaining the wires at least 1 inch from the surface wired over.

c. Multiple-conductor cables run on the exterior of building walls, unless especially approved for the purpose shall not be within eight feet from the ground, shall not be readily accessible and shall not be subject to mechanical disturbance. They shall be supported at intervals not exceeding 15 feet. Unless provided with a lead sheath or with armor, they shall be mounted upon insulating supports so as to be separated at least two inches from the surface wired over.

d. Open wires on exterior of buildings shall have approved rubber or weatherproof coverings for single wires and approved rubber insulation between conductors for multiple-conductor cables.

e. Rigid steel conduit or electrical metallic tubing made raintight, or multiple-conductor cable approved for the purpose, shall be used for wiring on exterior of buildings wherever open wiring cannot comply with the requirements of this order, and may be used in lieu of such open wiring under any conditions. For voltages exceeding 600, see Order 1350.02.

Order 1304.04. Entrance, Overhead and Underground.

a. Service entrance conductors shall enter the building at a point as near as practicable to the required service equipment and, in the case of overhead service, shall be without a splice between the terminals of such equipment and the point of attachment to the service drop. Conductors other than service conductors or grounding conductors shall not be installed in the service raceways. Service entrance conductors shall not be run within the hollow spaces of frame buildings unless provided with automatic over-current protection at their outer end.

Note: Clamped or bolted connections in a meter inclosure, and taps as permitted in 1304.01–d and 1304.05–b–1, are not prohibited.

b. Service entrance conductors shall be not smaller than No. 8.

Note: It is recommended that present and future demands of installations be considered with reference to two or three wire service and also with reference to size of wire and switch.

c. Except as provided in paragraph e of this order, the service entrance conductors of an overhead service shall be rubber-covered from the point of their attachment within the building to the terminals of the required service equipment at least to the first joint or splice clear of conduit, tubing or cable on the outside of the building.

d. Underground service entrance conductors shall, except as provided in paragraph e of this order, have rubber or some other approved insulation and shall be protected from moisture by a covering of lead or by other means approved

for the purpose; and where inside the building shall have mechanical protection in the form of rigid or flexible conduit, the metal tape of an approved type of service cable or other approved means.

e. In the case of supply systems, the secondaries of which have a maximum voltage to ground of not over 150 volts and which are elsewhere grounded outside the premises at two or more locations not in the same building to a continuous underground metallic piping system, a grounded neutral service entrance conductor without an insulating covering shall be permitted, provided it is also grounded to a waterpipe electrode at the service equipment. Such a bare grounded neutral conductor from an overhead supply shall be in rigid conduit, electrical metallic tubing, or an approved type of service entrance cable, and if an underground service conductor shall be run in grounded rigid conduit or electrical metallic tubing between the service equipment and the building end of the underground duct.

f. Where a service run of grounded rigid conduit or electrical metallic tubing is interrupted by flexible metallic conduit, the two ends of conduit or tubing thus interrupted or the end of the conduit or tubing and the service cabinet if the flexible conduit is connected thereto, shall be bonded together by a copper wire not smaller than No. 8, using approved clamps or other approved means, and both the bonding devices and bonding wire shall, if exposed to mechanical injury, be effectively protected therefrom.

g. Overhead service conductors shall enter buildings in rigid conduit, electrical metallic tubing, service entrance cable approved for the purpose or as separate individual wires. Where open wires are used, drip loops shall be formed on the individual wires which shall then pass upward and inward through slanting, non-combustible, non-absorptive insulating tubes. Where rigid conduit or electrical metallic tubing is used, all joints exposed to the weather shall be made raintight, and the raceway shall be arranged to drain. The raceway or cable shall be equipped with an approved raintight service head.

Where service switch is inside building, it is recommended that conductors entering the building from overhead lines be encased in approved rigid steel conduit.

h. Where a service pipe 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 and gases.

i. Where conduit or electrical metallic tubing is used to contain service conductors, the inner end of the conduit or tubing shall enter a terminal box or service switch cabinet or be made up directly to an equivalent device, enclosing all live metal parts, except that where the service switch is installed on a switchboard which has exposed busbars on the back, the conduit or tubing may terminate back of the switchboard, in which case it shall be equipped with a bushing which, except where lead covered conductors are used, shall be of the insulating type.

j. Service raceways and the metal sheaths of service entrance 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.

Order 1304.05. Service Equipment.

a. Wherever in this order a fuse is called for, the requirement may be met by use of a circuit-breaker approved for the purpose. Wherever a switch, or a switch and fuses, are called for, the requirement may be met by the use of an approved manually operable circuit-breaker. If a circuit-breaker is used, there shall be an over-current unit in each ungrounded conductor of the circuit. The switch or circuit-breaker shall plainly indicate whether it is open or closed. For settings of circuit-breakers see Section 130.8.

b. Except as otherwise provided below and in paragraphs h and i of this order, a service switch and fuses, of types approved for the prevailing conditions, such as exposure to the weather, shall be provided for each set of service entrance conductors and located at the nearest readily accessible point to the entrance of the conductors either inside or outside of the building wall.

1. In a building supplied at not more than 150 volts to ground, a single set of service entrance conductors may be run to 2, 3, or 4 sets of service equipment, if grouped at the point of service entrance; but for installations involving more than four separate subdivisions the entire current shall be taken through one main set of service equipment. Each service entrance conductor shall be continuous to the last set of service equipment which it supplies or to its bus on a switchboard. Taps may be used for the connections to the other sets.

2. The switch and fuses may be omitted in service conductors supplying a single-family residence having not

more than six branch circuits if the installation is according to sub-paragraph 3 of paragraph i of this order and if approved-type circuit-breakers are used in each branch circuit and these are grouped in a single readily accessible cabinet at the point of service entrance, provided the circuit-breakers may be operated and reset without opening the cabinet, that approved means are available within the cabinet for opening the grounded conductor and that the ungrounded service conductors are not exposed to contact when the door of the cabinet is open or its cover removed.

c. The service switch shall be installed in one of the following ways:

1. As an air-break or oil-immersed switch mounted on a switchboard or panelboard which is accessible to qualified persons only.

2. As an air-break or oil-immersed switch inclosed in a metal case. An inclosed service switch shall be externally operable and readily accessible unless additional switches are provided for control of all individual feeders and circuits supplied through it.

It is recommended that where the current of a single circuit, or group of circuits, is separately metered, as in apartment-house installations, a switch and cutout be installed to control each separately metered installation, the switch and cutout being inclosed and the switch being externally operable. The location of this switch and cutout may, or may not, be close to the meter.

d. The service switch shall have a rating not less than the rating of the cutout base or the setting of the circuit-breaker in series with it. Except by special permission, 30 ampere switches shall not be used for a two-wire service supplying more than two branch circuits, nor for a three-wire service supplying more than four branch circuits.

It is recommended that the service switch have, in all cases, a rating not less than 60 amperes and the circuit-breaker not less than 50 amperes.

e. The service switch shall simultaneously interrupt all conductors of the circuit in which it is placed except that:

1. Where switch and fuses are mounted in an approved sealable cabinet or where a service switch is mounted on a switchboard, the switch blade may be omitted in any grounded service conductor if other approved means are provided within the cabinet or on the switchboard for disconnecting such grounded neutral conductor.

2. A switch controlling a 3-wire direct-current or a 3-wire single-phase system may be so designed that one outside conductor can be opened without opening the other outside conductor.

f. Except as provided in sub-paragraphs 1 and 2 of paragraph b of this order, each ungrounded service entrance conductor shall have connected in series with it a fuse of rating not higher than the allowable carrying capacity of the conductor as stated in the table of Order 1306.12 of Section 130.6, except that the authority enforcing this code may permit a higher rating when necessary on account of motor-starting currents, in which case the ratings may be determined upon in view of Order 1308.08. If the service fuses are locked or sealed, or are located at the outer end of the service raceway, branch fuses connected on the load side of the meter shall be accessible to persons concerned, and need not be close to the meter. If such an installation consists of a single branch circuit, the branch fuse or fuses shall be of smaller rating than the service fuse or fuses.

g. No fuse or circuit-breaker shall be placed in a grounded service conductor except that a circuit breaker which simultaneously opens all conductors of the circuit may be used.

h. The service fuse or fuses shall cut off current from all circuits and devices other than the service switch which are supplied by the service entrance conductors, except that,

1. A service entrance conductor for a system supplying emergency illumination may be connected on the supply side of other service entrance equipment if in conformity with paragraph a of Order 1341.03 of Section 134.1.

2. Where outside current supply is utilized for the operation of fire alarm or other protective signaling system, connection for such purposes may be made ahead of the service switch and fuses, and shall be separately fused.

3. Under certain conditions as given in paragraph i of this order, the meter may be on the supply side of the service fuses as well as of the service switch.

4. High-impedance shunt circuits for measuring and control apparatus, such as potential coils of meters and control circuits of time switches, may be connected on the supply side of the service switch and fuse. The wiring method for such control circuits shall be one specified in this code for service entrance conductors.

i. The relative arrangement of the service switch and fuses and the meter shall provide that the switch shall be on the supply side of the fuse and that the meter shall be protected by the fuse, except that

1. Service fuses may be located at the outer end of the service raceway.

3. Where the meter is installed in conjunction with sealable equipment with no live parts or wiring exposed, on alternating-current circuits not exceeding 300 volts between conductors, the meter may be placed on the supply side of the switch and fuses, provided the rating of the latter does not exceed 100 amperes. In service equipment arranged as in sub-paragraph 1 of paragraph b of this order a meter may be installed ahead of each such set of service equipment individually limited to 100 amperes or one meter may be ahead of all if the total rating does not exceed 100 amperes.

j. Where not located on a switchboard or panelboard, accessible only to qualified persons, live parts of switches, buses, fuses, cutout bases and circuit-breakers shall be inclosed so that they will not be exposed to accidental contact. The inclosure shall be grounded in accordance with the method for equipment grounding given in Section 130.9. This grounding may be omitted where inclosures are isolated from conducting surfaces and unexposed to contact by persons or materials that may be in contact with other conducting surfaces including other inclosures, conduit, etc., and where also the voltage does not exceed 150 volts to ground and no contained live parts are connected to ungrounded circuits exposed to more than 150 volts to ground.

k. In a property comprising more than one building under single management and which has a generating plant or is served by a master service, the conductors running from one building to another shall not be considered as service conductors, in that fuses or circuit-breakers will not be required where these supply the wiring installation within any building, provided that the fuses or circuit-breakers next back on these conductors properly protect the conductors within that building, and provided that each such set of conductors is separately controlled by a suitable feeder-control switch which is readily accessible to those persons using that installation. Such switch may be located at the entrance of the conductors to the individual building or farther back on the feeder concerned. The provisions of this paragraph also apply to garages and similar outbuildings of residential installations.

1. When service conductors carry a voltage exceeding 600 volts between conductors, the requirements of Order 1350.08 of Section 135.0 shall apply.

Order 1304.06. Hazardous Locations.

a. When it is necessary to place service equipment in the Class I, Class II, Class III or Class IV locations defined in paragraphs (b), (c), (d) and (e), respectively, of Order 1332.01, the provisions of paragraph b of Order 1332.03, paragraph (b), Order 1332.04, paragraph (b), Order 1332.05, and paragraph (b) of Order 1332.06, respectively, shall be observed.

SECTION 130.5. WIRING METHODS

This article treats only of types of wiring recognized as suitable and of the conditions and methods of installation under which they are suitable. Special types of wiring may be used only where recognized as suitable under this and other articles of this Code. The recognized types of wiring may be installed in any type of building or any type of occupancy except as otherwise provided in any article of this Code.

Where ground resistance below 3 ohms cannot be obtained, attention should be paid to the selection of a suitable wiring method. In such a case metallic raceway systems should not be used for the interior wiring but may be used for the service entrance.

Order 1305.00. Wiring Installation Design.

a. See Section 132.0 of this code for regulations as to polarity identification which appeared in this order in previous editions of the State Electrical Code.

Order 1305.01. Open Wires.

a. Single conductor wires may be installed as open wires upon walls, and ceilings, when the provisions of the following paragraphs of this section shall be observed.

b. In dry places wires shall be of approved rubber-covered (R), slow-burning weatherproof (SBW), varnished-cambric insulated (VC), slow burning (SB) or asbestos-covered type (A).

c. In damp places or in buildings especially subject to moisture wires shall be of the rubber-covered type.

d. Wires subjected to corrosive vapors shall be of the weather-proof, varnished-cambric or rubber covered type, (as may be directed by the authority enforcing this code).

e. Where the environment is such that rapid deterioration of conductors or insulation is probable, the authority enforcing this code may require the wires to be suitably enclosed, coated or otherwise protected to better withstand the particular conditions of service.

f. Wires entering or leaving buildings or rooms subject to moisture 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 room, subject to moisture or corrosive vapors, through non-combustible, non-absorptive tubes.

g. Wires shall not be laid in plaster, cement or similar finish, nor fished for any great distance or where it will not be clearly evident that the rules have been complied with.

h. Wires shall not be fastened with staples.

i. Wires of No. 8 or larger supported on solid knobs shall be securely tied thereto. If wires are used for tying, they shall have an insulation of the same type as that of the wires which they confine.

j. Wires shall be rigidly supported; 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 for voltages from 301 to 600 volts the wires shall be separated 4 inches from each other and one inch from the surface wired on. In damp places a separation of at least 1 inch from the surface wired over shall be maintained for all voltages.

Note: (1) Rigid supporting requires under ordinary circumstances, when wiring over flat surfaces, supports at least every 4½ feet, this interval being shortened if the wires are liable to be disturbed. 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; this construction may also be employed in factory buildings and under these conditions wires shall be supported at the end by strain insulators and at each intermediate column or roof truss with insulating supports.

(2) In large interiors where it is advantageous to run wires through space, unsupported except at ends, the following conditions shall be observed:

I. Wires must be elevated at least 16 feet and not subject to mechanical injury.

II. Spans must not exceed 75 feet for No. 8 A. W. G. wire or 125 feet for No. 6 A. W. G. or larger wire.

III. Wires shall not be smaller than No. 8 A. W. G. wire.

IV. Wires shall be supported at ends by strain insulators.

k. Open wires shall not be dead-ended at a rosette, socket or receptacle unless the last support is within 12 inches of the same.

l. Where open wires cross ceiling joists and wall studs and are exposed to mechanical injury, they shall be protected by one of the following methods. Wires within seven feet from the floor shall be considered exposed to mechanical injury.

1. 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.

2. By a substantial running board back of the wires with side protections, made of at least one-half inch stock. Running boards shall extend at least one inch outside the wires, but not more than two inches and the protecting sides shall be at least two inches high and at least ⅞ inch thick.

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

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

5. Insulated conductors of more than 300 volts to ground, or open, bare, ungrounded conductors of all voltages, of less than 8 feet above the floor or working platform and accessible to unqualified persons, shall be guarded by approved screens, barriers, or enclosures.

m. Where a change is made from open wiring to conduit, electrical metallic tubing, surface metal raceways or armored cable, an approved terminal fitting having a separate bushed hole for each wire shall be used, through which fitting the wires shall pass without splice, joint or tap within the fitting. This terminal fitting need not be accessible.

n. Open wires located in damp places shall be so placed that an air space will be permanently maintained between them and pipes which they cross.

Note: Wires run in close proximity to water pipes or tanks are considered to be exposed to moisture. It is recommended that wires be run over, rather than under, pipes upon which moisture is likely to gather or which may leak.

o. Open wires shall be separated from contact with walls, floors, timbers or partitions through which they pass by tubes or bushings composed of approved non-combustible, non-absorptive, insulating material. If the bushing is shorter than the hole, a waterproof sleeve such as an iron pipe, shall be inserted in the hole and an insulating bushing slipped into the sleeve at either end and in such a manner as to keep the wire absolutely out of contact with the sleeve.

p. Open wires shall be permanently separated from adjacent metallic piping or other conducting material, or from any exposed lighting, power or signal wire which approaches within 2 inches by a firmly fixed and continuous non-conductor, additional to the insulation on the wire. Where an insulating tube is used, it shall be secured at the ends.

Note: Deviations from this requirement may, where necessary, be allowed by the authority enforcing this code.

q. Wires in unfinished accessible attics or roof spaces shall be treated as though concealed and have the spacing between wires and clearance from the surface wired over as required for concealed knob-and-tube work in Order 1305.02, and shall also be subject to the following provisions:

1. When run within seven feet of the floor or floor joists, through bored holes in rafters or studs, or when run through bored holes in floor joists, wires shall be protected by substantial running boards extending at least one inch on each side of the wire or wires and securely fastened in place.

2. When run across the edges of floor joists, or across the edges of rafters or studding within seven feet of the floor or floor joists, wires shall be protected by substantial guard strips at least as high as the insulating supports. Wires shall be supported on insulators at each floor joist.

3. When carried along the sides of rafters, studs or floor joists, neither guard strips, nor running boards shall be required.

r. Open wires shall not be placed in hoistways.

s. Supports shall be composed of approved non-combustible, non-absorptive insulating material, free from checks, rough projections or sharp edges which might injure the insulation on the conductor. If the supports are designed to grip the wires, either screws or nails may be used to fasten the supports in place. Nails or screws shall be long enough to penetrate the woodwork not less than ½ the depth of the knob and fully the thickness of the cleat. Cushion washers shall be used with nails.

t. Supports shall provide at least ¼ inch separation between the securing screw or nail and the wire, and shall be designed for two securing screws if the split-knob (or single-wire cleat) type intended for wires larger than No. 4.

u. Multi-wire cleats shall be so designed as to separate the wires at least 2½ inches and maintain them at least ½ inch from the surface wired over. Such cleats shall not

be employed to support wires operating at a potential exceeding 300 volts.

v. Knobs shall be so designed as to maintain the wire at least 1 inch from the surface wired over, and shall conform to the following dimensions:

Size of Wire Inclusive	Size of Base, Inches			Solid Knobs, Groove, In.		Split Knobs, Thickness of Cap, Inches from Top of Wire Groove.
	Circular Knobs Diameter	Square Knobs or Single Wire Cleats				
		Width	Length	Depth	Diameter	
14–10	1⅛	¾	1¾	3/16	¼	⅜
8–4	1½	⅞	2	5/16	5/16	5/8
2–00	2	1	2¼	7/16	⅝	5/8
000–300,000 C. M.	2½	1⅛	2¾	7/16	21/32	⅞
400,000–1,000,000 C.M	3	1⅜	3¾	⅝	1¼	1

w. Tubes and bushings shall conform to the following minimum dimensions.

Diameter of Hole	External Diameter	Thickness of Wall	External Diameter of Head	Length of Head
5/16 in	9/16 in.	⅛ in.	13/16 in.	½ in.
⅜	11/16	5/32	15/16	½
½	13/16	3/32	1 3/16	½
⅝	13/16	5/32	1 5/16	½
¾	1 3/16	3/32	1 13/16	⅝
1	1 7/16	3/32	1 15/16	⅝
1¼	1 15/16	5/32	2 5/16	⅝
1½	2 7/16	3/32	2 11/16	¾
1¾	2 9/16	3/32	3 1/16	¾
2	2 15/16	3/32	3 7/16	¾
2¼	3 3/16	1/32	3 13/16	1
2½	3 11/16	1/32	4 5/16	1

An allowance of 1/64 of an inch for variation in manufacturing will be permitted except in the thickness of the wall.

Order 1305.02. Concealed Knob and Tube Work.

a. Single conductor wires mounted with knobs and tubes or run in non-metallic flexible tubing as in paragraph f, below, may be installed as concealed work in the hollow spaces of walls and ceilings, when the provisions of the following paragraphs of this section shall be observed.

b. Concealed knob and tube work shall not be used for systems of more than 300 volts between conductors or more than 150 volts to ground.

c. Supports shall conform to the requirements for knobs, tubes and bushings, as prescribed in Order 1305.01 of this code.

d. Wires shall be of approved rubber-covered type (R).

e. Wires shall be separated at least 5 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 5 inch separation cannot be maintained, each wire shall be encased in a continuous length of approved flexible tubing.

Note: It is recommended that wires be run singly on separate timbers or studding.

f. Where it is impracticable to employ insulating supports, the wires, if not exposed to moisture, may be fished if separately encased in approved flexible tubing extending in continuous lengths from one support to the next or to the outlet, or from one outlet to another; otherwise, approved conduit, approved armored cable, approved electrical metallic tubing or approved non-metallic sheathed cable shall be used.

g. Where a change is made from concealed work to conduit, electrical metallic tubing, surface metal raceways or armored cable, an approved terminal fitting having a separate bushed hole for each wire shall be used, through which fitting the wires shall pass without splice, joint or tap. This terminal fitting need not be accessible.

h. In installing wires the precautions as to rigid supporting, clearance from foreign wires and objects, drip loops where moisture or corrosive vapors are present, as prescribed in Order 1305.01 of this code, shall be observed. Wires passing through cross timbers in plastered partitions shall be protected by an additional tube extending at least three inches above the timber.

i. Approved outlet boxes as required by paragraph a of Order 1305.12 shall be installed at all outlets and switch points and the flexible tubing shall extend from the last knob into and be secured to such boxes.

j. When thermal insulation is used in the hollow spaces of walls and ceilings in which concealed knob-and-tube work is installed, only approved non-corrosive, non-combustible, non-conducting thermal insulation materials shall be used, and these shall be applied in a manner not liable to place a strain upon the wires or supports.

Order 1305.03. Conduit Work.

a. When conduit work, rigid or flexible, is the wiring method employed, the provisions of the following paragraphs of this section shall be observed.

b. Rigid steel conduit tube and all elbows, bends, couplings and similar fittings which constitute a part of the conduit system shall, unless made of non-corrodible metal, be suitably protected against corrosion inside and outside, excluding threads at joints, by an approved coating of corrosion-resistive material such as zinc, or enamel, or by combinations of both.

c. Flexible metallic conduit and all couplings, connectors and similar fittings which constitute a part of the conduit system shall, unless made of non-corrodible metal, be suitably protected against corrosion by an approved coating of corrosion-resistive metal such as zinc.

d. No conduit smaller than ½ inch, electrical trade size, shall be used except as provided for under-plaster extensions in Order 1305.10 of this order, and for inclosing the leads of fractional horsepower motors as permitted in paragraph a of Order 1310.03 of Section 131.0.

e. Rigid steel conduit, as shipped, shall be in 10-foot lengths including couplings, with each end reamed and threaded, and shall have an interior coating of a character and appearance which will readily distinguish it from ordinary pipe commonly used for other than electrical purposes. One coupling shall be furnished with each length.

Note: It is recommended that the protective coating on the outer surface of conduit, elbows, bends, couplings and similar fittings be of conductive material, such as cadmium, tin or zinc, in order to secure better electrical contact.

CONDUIT SIZES AND WEIGHTS

Stand. Pipe Size Inches	Nominal Diameter, Inches		Threads per Inch	Minimum Wt. Lbs. of Ten 10-foot Lengths of Finished Conduit with Couplings Attached
	Inside	Outside		
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

f. Bends of rigid or flexible metallic conduit shall be so made, that the conduit will not be injured. The radius of

the curve of the inner edge of any field bend shall be not less than six times the internal diameter of the conduit. Care shall be taken to see that bends in conduit are so made as to avoid reducing the internal diameter of the conduit at the bend.

g. Conduit shall be installed as a complete system without the wires, and shall be continuous from outlet to outlet and from fitting to fitting, and shall be mechanically and electrically connected to all fittings. The fittings connected to more than one run of conduit shall be so designed and connected that adequate electrical continuity from one conduit to another will be secured. Threadless type couplings and connectors shall always be made up tight, and where buried in concrete or fill or in masonry walls or used on runs in wet places, shall be of the approved watertight type. The entire system shall be securely fastened in place.

h. Approved outlet boxes or fittings as required by paragraphs a and b of Order 1307.03 shall be installed at all outlets and switch points.

i. A run of conduit, between outlet and outlet or between fitting and fitting, shall include not more than the equivalent of 4 quarter bends, the bends at the outlets or junction boxes not being counted.

j. All ends of conduit shall be reamed to remove rough edges, and where a conduit enters a box or other fittings, an approved 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.

k. Conduit shall be grounded as prescribed in Section 103 of this code.

l. Wires in conduit shall be of approved types that are suitable for the conditions prevailing at the particular location according to the following:

Where the temperature of the ambient air exceeds 120 F. (49 C.) the wire shall be of the asbestos-covered (Type A) type or shall have slow-burning (Type SB) insulation; with flexible conduit in wet or damp places rubber-covered wire with a lead covering (Type RL) shall be used; elsewhere rubber-covered wire (Type R) shall be used except that in permanently dry locations varnished cloth insulated (Type VC) wire may be used.

All wires No. 6 and larger shall have stranded conductors. There shall be no splice or tap within the conduit proper.

m. Wires shall not be drawn in until all mechanical work on that part of the building which is liable to injure the

wires has been completed, as far as possible. Pull wires, if used, shall not be installed until the conduit system is in place.

n. Wires of different systems shall not occupy the same conduit, outlet box, junction box, fitting, or cabinet. (See paragraph p of Order 1305.12.)

Note: (1) Different systems are those which derive their supply from (1) different sources of current, (2) transformers connected to separate primary circuits, or (3) transformers except instrument transformers having different secondary voltages.

(2) The intent of this rule is to prevent accidental cross connection between systems of different voltages or characteristics.

o. When alternating current is to be employed, all conductors of a circuit shall be placed within one conduit, except on circuits supplying vacuum and gas-tube lighting systems and signs, and X-ray apparatus, and as provided in Order 1305.10 of this section.

It is recommended that this course be pursued in the case of direct current also, in order to obviate induction troubles if a change is made to alternating current at a later date.

p. For conduit wiring installed underground or in concrete slabs or other masonry in direct contact with moist earth, or in other permanently moist locations where subject to the condensation of moisture, the conductors shall be of the lead covered type, or of other type specially approved for this purpose.

q. One conduit shall not contain more wires than as specified in Table 1 of this paragraph.

The following tables apply only to complete conduit systems, and do not apply to short sections of conduit used for the protection of exposed wiring from mechanical injury including sections not more than 12" in length between switches and boxes.

TABLE 1

Two-Wire and Three-Wire Systems

Size of Wire	Number of Wires in One Conduit								
	1	2	3	4	5	6	7	8	9
	Minimum Size of Conduit in Inches								
No. 14	½	½	½	½	¾	¾	¾	1	1
12	½	½	½	¾	¾	1	1	1	1¼
10	½	¾	¾	¾	1	1	1¼	1¼	1¼
8	½	¾	1	1	1	1¼	1¼	1¼	1¼
6	¾	1	1¼	1¼	1½	1½	2	2	2
5	¾	1¼	1¼	1¼	1½	2	2	2	2
4	¾	1¼	1¼	1½	1½	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1½	1½	1½	2	2	2½	2½	2½
1	¾	1½	2	2	2	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	1	2	2	2½	3	3	3½	3½	4
200000 C.M.	1¼	2	2½	2½	3	3	3½	3½	4
225000	1¼	2	2½	2½	3	3	3½	----	----
250000	1¼	2½	2½	3	3	3½	3½	----	----
300000	1¼	2½	2½	3	3	3½	4	----	----
350000	1¼	2½	3	3	3½	3½	4	----	----
400000	1¼	3	3	3½	3½	4	4	----	----
450000	1¼	3	3	3½	3½	4	4½	----	----
500000	1½	3	3	3½	3½	4	4½	----	----
550000	1½	3	3	3½	4	4½	5	----	----
600000	1½	3	3½	4	4	4½	5	----	----
650000	2	3	3½	4	4	----	----	----	----
700000	2	3½	3½	4	4½	----	----	----	----
750000	2	3½	3½	4½	4½	----	----	----	----
800000	2	3½	3½	4½	4½	----	----	----	----
850000	2	3½	4	4½	4½	----	----	----	----
900000	2	3½	4	4½	4½	----	----	----	----
950000	2	4	4	4	5	----	----	----	----
1000000	2	4	4	5	5	----	----	----	----
1100000	2½	4	4½	4½	6	----	----	----	----
1200000	2½	4½	4½	4½	6	----	----	----	----
1250000	2½	4½	4½	4½	6	----	----	----	----
1300000	2½	4½	5	5	6	----	----	----	----
1400000	2½	4½	5	5	6	----	----	----	----
1500000	2½	4½	5	5	6	----	----	----	----
1600000	2½	5	5	5	6	----	----	----	----
1700000	3	5	5	5	6	----	----	----	----
1750000	3	5	5	6	6	----	----	----	----
1800000	3	5	5	6	----	----	----	----	----
1900000	3	5	5	6	----	----	----	----	----
2000000	3	5	5	6	----	----	----	----	----

Not more than 9 wires shall be permitted in one conduit except as noted in Table 3.

Permissible exceptions to Table 1:

Stage pocket and border circuits, sign flashers, Classes 1, 2 and 3 signal circuits (see Section 136.0), elevator control wires and wires between controllers and motors and otherwise as permitted by the authority enforcing this code (see Table 3 following). In addition the following exceptions are permitted where the run of rigid 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; three No. 6 stranded or six No. 8 solid conductors in a 1-inch conduit; and for services only, two No. 6, Type R, and one No. 6, bare, wires, two No. 4, Type R, and one No. 4, bare, wires, in

1-inch conduit and two No. 2, Type R, and one No. 2, bare, wires in 1¼-inch conduit. See 1304.04–e.

A smaller bare wire may be used in each of the above combinations if of suitable current-carrying capacity.

TABLE 2

Three-Conductor Convertible System

Size of Wires	Size Conduit Electrical Trade Size
two 14 and one 10	¾ inch
two 12 and one 8	¾ inch
two 10 and one 6	1 inch
two 8 and one 4	1 inch
two 6 and one 2	1¼ inch
two 5 and one 1	1¼ inch
two 4 and one 0	1½ inch
two 3 and one 00	1½ inch
two 2 and one 000	1½ inch
two 1 and one 0000	2 inch
two 0 and one 250000	2 inch
two 00 and one 350000	2½ inch
two 000 and one 400000	2½ inch
two 0000 and one 550000	3 inch
two 250000 and one 600000	3 inch
two 300000 and one 800000	3 inch
two 400000 and one 1000000	3½ inch
two 500000 and one 1250000	4 inch
two 600000 and one 1500000	4 inch
two 700000 and one 1750000	4½ inch
two 800000 and one 2000000	4½ inch

TABLE 3

Stage Pocket and Border Circuits, and Elsewhere by Special Permission

Size of Wire	Maximum Number of Wires in Conduit					
	Inch 1	Inch 1¼	Inch 1½	Inch 2	Inch 2½	Inch 3
14	11	19	26	43	61	95
12	----	15	21	34	50	77
10	----	12	16	27	38	60
8	----	----	13	22	31	49
6	----	----	----	----	14	22

TABLE 4

Lead Covered Wires and Cables—600 Volts

Size of Wire	Size of Conduit to Contain Not More than Four Cables											
	Single Conductor Cable				2-Conductor Cable				3-Conductor Cable			
	1	2	3	4	1	2	3	4	1	2	3	4
	Cables in One Conduit				Cables in One Conduit				Cables in One Conduit			
14	¾	¾	¾	¾	¾	1	1	1¼	¾	1¼	1½	1½
12	¾	¾	¾	1	¾	1	1¼	1¼	1	1¼	1½	2
10	¾	¾	1	1	¾	1¼	1¼	1½	1	1½	2	2
8	¾	1	1	1¼	1	1¼	1½	2	1	2	2	2½
6	¾	1¼	1¼	1½	1¼	1½	2	2½	1¼	2½	3	3
4	¾	1½	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
250,000	1¼	2½	3	3	-----	-----	-----	-----	3	6	6	-----
300,000	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
350,000	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
400,000	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
450,000	1½	3	3	4	-----	-----	-----	-----	4	6	6	-----
500,000	1½	3	3½	4	-----	-----	-----	-----	4	6	-----	-----
600,000	2	3½	4	4½	-----	-----	-----	-----	-----	-----	-----	-----
700,000	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
750,000	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
800,000	2	4	4½	5	-----	-----	-----	-----	-----	-----	-----	-----
900,000	2½	4	4½	5	-----	-----	-----	-----	-----	-----	-----	-----
1,000,000	2½	4½	4½	6	-----	-----	-----	-----	-----	-----	-----	-----
1,250,000	3	5	5	6	-----	-----	-----	-----	-----	-----	-----	-----
1,500,000	3	5	6	6	-----	-----	-----	-----	-----	-----	-----	-----
1,750,000	3	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----
2,000,000	3½	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----

The above sizes apply to straight runs or with nominal offsets equivalent to not more than two quarter-bends.

It is recommended that bends have a minimum radius of curvature at the inner edge of the bend of not less than 10 times the internal diameter of the conduit.

For groups or combinations not included in the above tables, consult the authority enforcing this code. For such groups or combinations, it is recommended that the conduit be of such size, that the sum of the cross-sectional areas of the several conductors will not be more than 40 per cent of the interior cross-sectional area of the conduit.

r. Wires in vertical conduits shall be supported at the following intervals:

No. 14	to No. 0	Not greater than 100 feet.
No. 00	to No. 0000	Not greater than 80 feet.
No. 0000	to 350000 C. M.	Not greater than 60 feet.
350001 C. M.	to 500000 C. M.	Not greater than 50 feet.
500001 C. M.	to 750000 C. M.	Not greater than 40 feet.
above	750000 C. M.	Not greater than 35 feet.

Note The following methods of supporting cables are recommended:

(1) By approved clamping devices constructed of or employing insulating wedges inserted in the ends of the conduits.

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

(3) In approved 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 the wires if desired.

s. Vertical wires of 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.

Feeder Size (A. W. gauge)	Minimum Width of Gutter in Inches
1	3
0–200,000 cm.	4
211,600 cm. to 500,000 cm.	6
600,000 cm. to 900,000 cm.	8
1,000,000 cm. to 1,400,000 cm.	10
1,500,000 cm. to 2,000,000 cm.	12

Order 1305.04. Surface Metal Raceways.

a. When wires are installed in surface metal raceways the provisions of the following paragraphs of this section shall be observed.

b. Raceways shall be of approved types and shall be used only in exposed dry locations and where the maximum difference of potential does not exceed 300 volts between conductors nor 150 volts to ground. They shall not be placed in hoistways nor where they may be subjected to severe mechanical injury nor where corrosive vapors are present. (For use in under plaster extensions see Order 1305.10 of this section.)

c. Wires shall be of approved rubber-covered types, and shall be continuous from outlet to outlet, or from fitting to fitting, no joints or taps being located in the raceway proper except that with metal raceways, wires exposed to surrounding temperatures exceeding 120° F. (49° C.) shall be type (A) or type (SB).

d. Surface metal raceways shall not be used for wires larger than No. 8 or fused at more than 30 amperes nor for a number of wires greater than that for which the raceway is approved and in no case for more than ten wires except as otherwise expressly permitted elsewhere in this code. (See 1337.03–n and 1360.02–b–3)

e. Metal raceways shall be of such construction as will distinguish them from rigid conduit. All surfaces of raceway, elbows, bends and similar fittings shall be suitably protected from corrosion.

f. 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.

g. Where alternating current is to be employed in connection with metal raceway work, all wires of a circuit shall be placed in one raceway, except as provided in Order 1305.10 of this section.

Note: It is recommended that this course be pursued in the case of direct current also, in order to obviate induction troubles if a change is made to alternating current at some later date.

h. The metal raceway shall be continuous from outlet to outlet, or from approved fitting to approved fitting, and shall be securely fastened in place. It may be extended through dry walls, dry partitions, or dry floors, if in unbroken lengths where passing through.

i. Metal raceways shall be grounded as prescribed in Section 103 of this code.

j. When 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 compartment shall be maintained throughout the premises, in which case the provisions of paragraph p, Order 1305.12, and of Order 1360.02 of this code, shall be considered as having been observed. When such combination metal raceways are used, ten No. 14 wires shall be permitted in the compartment for light, heat and power circuits. Extension of light and power circuits to and from combination metal raceways shall be in conduit connected to the raceways with approved fittings. In all other respects, the provisions of this order covering single compartment raceways, shall apply.

Order 1305.05. Armored Cable.

a. When armored cable, types AC or ACL, is used as the wiring method, the provisions of the following paragraphs of this section shall be observed.

b. Armored cable shall not be used for systems of more than 600 volts nor where its surrounding temperature will exceed 120° F. (49° C.)

c. Type AC armored cable may be used for open or concealed work in dry locations and may be fished; when run on walls of brick or similar masonry it may be embedded in the plaster finish except where this is prohibited by the authority enforcing this code, because of excessive humidity.

d. Armored cable shall be of Type ACL, when used for underground runs and on other circuits where imbedded in masonry, concrete, or fill in buildings in course of construction, and elsewhere if the location is such that the cable will be exposed to weather, continuous moisture, excessive humidity, or if exposed to oil, gasoline or other materials having a deteriorating effect on rubber insulation.

e. Approved outlet boxes or fittings shall be installed at all outlets and switch points as provided in paragraph a of Order 1305.12. The cable shall be continuous from outlet to outlet, or from fitting to fitting, and the armor shall be mechanically and electrically connected to all fittings in a manner to substantially close the openings at entrance points and to hold the cable securely.

f. Except where cable is fished, it shall be secured in place by approved fastenings spaced at intervals not exceeding 4½ feet; and shall be securely fastened within 12 inches of every outlet box or fitting.

g. At all points where the armor terminates, an approved fitting shall be provided to protect wires from abrasion, unless the design of the outlet boxes or fittings required by paragraph e of this order 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.

h. 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 five times the diameter of the cable.

i. When, in exposed or concealed wiring, cable is run through bored holes in studs, joists or similar wood members, such holes shall be bored at the approximate center of such timbers or at least two inches from the nearest edge.

j. When the cable is employed in accessible attics or roof spaces, it shall be installed as follows:

1. When within seven feet of floor or joists, across the face of rafters or studding, or across the top or face of

floor joists, cable shall be protected by substantial guard strips at least as high as the cable.

2. When carried along the sides of rafters, studs or floor joists, neither guard strips, nor running boards shall be required.

k. For the use of armored cable in under-plaster extensions, see Order 1305.10 of this Section.

l. When alternating current is to be employed, all conductors of a circuit shall be contained within one armor except on circuits supplying vacuum and gas tube lighting systems and signs and X-ray apparatus, and except as provided in Order 1305.10 of this section.

Note: It is recommended that in the case of direct current also all conductors of a circuit be placed within one armor, in order to obviate induction troubles if a change is made to alternating current at a later date.

m. The armor shall be grounded as prescribed in Section 103 of this Code.

Order 1305.06. Underfloor Raceways.

a. Underfloor raceways shall be used only in dry locations, free from corrosive, hazardous and extra hazardous conditions, in buildings of fire-resistive construction and where embedded in concrete or concrete fill of floors which are of sufficient thickness to exceed the height of raceways at all points. They shall not be used for circuits of more than 300 volts nor for any wire larger than No. 8 nor any wire protected by an automatic overcurrent protective device exceeding 30 amperes.

b. Underfloor raceways shall be of an approved type and may be placed in the concrete fill between the rough and the finished floor where there is at least 1 inch of concrete placed above the raceway, except that with a duct of approximately round or half round section, or of flat top section not exceeding 1½ inches in width, this may be reduced to ¾ inch. Upper surface of flat top ducts shall not be more than 4 inches wide nor shall be placed side by side without at least ½ inch of intervening concrete, or unless cover depth is increased to 1½ inches. Open bottom types of underfloor raceways shall not be used in floors of monolithic construction.

c. Open-bottom types of underfloor raceways shall not be used in shallow-floor concrete fills unless proper cover is maintained and a smooth pad of 1 inch concrete having a margin of at least 1 inch on either side of the raceway, or unless approved fittings are used which will protect the wiring from contact with piping, structural steel or other obstructions, except that where transverse conduit is encountered the pad thickness may be reduced to ¼ inch. Open-bottom type shall have under it the above required pad except where approved fittings are so installed as to protect the wiring from contact with and leakages to piping, structural steel or other obstructions below.

d. 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 raceways. Raceways shall be made mechanically secure to prevent disturbing this alignment during construction.

e. All joints along edges of raceways and between raceways, couplings and junction boxes, and between junction boxes cover plate and cover ring shall be filled with an approved waterproof cement, but with metal raceway this shall not interrupt the required electrical continuity of the raceway. Approved fittings may be used to take the place of waterproof cement between junction boxes, cover plate and cover ring. Raceways, with their fittings, should be so arranged, that there will be no low points, or traps in the raceway run. Crossing shall be avoided wherever practical.

f. Where raceways are run at other angles, than right angles, special fittings shall be provided, if in the judgment of the authority enforcing this regulation, these are necessary. Connections between raceways and distribution center, or the side wall outlets, shall be by means of conduit or approved fittings. Electrical continuity shall be maintained for metal raceways and fittings. At every end of line of duct, 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 shall be deemed necessary at the interrupting point. Dead ends of ducts shall be closed.

g. Inserts for outlets and junction boxes shall be made in an approved manner, with approved fittings, and shall make a tight contact with the raceway. In the case of metal raceways, inserts and junction boxes shall be of metal, electrically continuous with the raceways. Inserts in fibre raceways shall be screwed into the fibre and shall not be set until floor is laid unless inserts are made me-

chanically secure by separately grouting them in. All inserts and junction boxes shall be carefully leveled to the floor grade and sealed with an approved watertight plug.

h. Care shall be exercised in setting inserts and when cutting through the raceway wall that chips and other dirt do not fall into the raceway. Special tools designed to eliminate this and to prevent the tools entering the raceway and injuring wires already there, shall be employed.

i. Underfloor metal raceways and all metal fittings, shall be of a type, and of such material, or protected by such coatings, as shall suitably resist corrosion, and any coating shall be such as will resist removal by ordinary handling.

j. Underfloor metal raceways shall be continuous from outlet to outlet, or from approved fitting to approved fitting.

k. Underfloor raceways of metal shall be electrically continuous and grounded as prescribed for other metal wiring raceways in Section 103 of this Code, and at a point as near as practical to the source of supply.

l. A combination type of underfloor raceway may be used for both signaling, and lighting and power wiring systems, provided the different wiring systems are run in separate compartments, and the same relative position of compartments is maintained throughout the premises.

m. Where open-bottom raceways are used, approved, double-braid rubber-covered wires, type RD, armored cable or non-metallic sheathed cable shall be used. Where it is impossible to install the required pad for crossing conduits or structural steel, only armored cable or non-metallic sheathed cable shall be used. Wherever armored cable is used it shall be grounded in accordance with Section 103 of this Code. For closed-bottom raceways approved rubber-covered wires, type R shall be used, or type RD, armored cable or non-metallic sheathed cable shall be used.

n. Wires used in underfloor raceways, either open or closed bottom shall be continuous from outlet to outlet, or from junction box to junction box, or from junction box to outlet. Wires shall have no joints or taps located in the raceway proper, nor at inserts. Joints or taps shall be made in junction boxes by splicing and soldering, or by use of an approved fitting, approved for the purpose. Armored cable and non-metallic sheathed cable shall be secured at the outlets by approved fittings.

Note: When an outlet is discontinued the wires feeding that outlet should be removed from the raceway.

o. Not more than ten wires shall be placed in any one raceway, nor shall the combined cross-sectional area of all conductors exceed 40 per cent of the interior cross-sectional area of the raceway; where only armored cable or non-metallic sheathed cable is contained this shall not apply. Wires or interior wiring systems not electrically connected to each other within the building shall not be contained within the same raceway.

p. Wires shall not be drawn in until all mechanical work on the building which is liable to injure the wires has been completed, so far as practical.

q. Where alternating current is to be employed for wires within a metal raceway the wires and circuits shall be so grouped that the current in one direction is substantially the same as that in the opposite direction.

Order 1305.07. Non-Metallic Sheathed Cable.

a. Cable shall not be used for circuits exceeding 600 volts between conductors nor where the ambient-air temperature will exceed 120° F. (49° C.).

b. Cable shall not be installed in masonry, concrete or fill nor be buried in plaster. Thermal insulation of approved non-corrosive, non-combustible, non-conducting materials may be used in hollow spaces in walls or ceilings in which such cable is installed. Such thermal insulation shall be so installed that strain will not be placed on the cable, its supports, or terminal connections.

c. Cable shall be of approved type, in sizes 14 to 4 inclusive and in two or three-wire assemblies and in addition may have an approved size of non-insulated copper conductor laid in next to the insulated conductors to be used only for grounding purposes.

d. When employed for exposed wiring, cable shall be installed as follows:

1. Shall be mounted directly upon and unless substantial running boards are used, shall closely follow the surface of woodwork, plaster, cement, brick or other building finish.

2. Shall be secured to surfaces with approved fastenings, spaced at intervals not exceeding four and one-half feet, and shall be securely fastened within 12 inches of every outlet box or fitting.

3. Cable run in locations where it may be exposed to mechanical injury shall be protected by rigid conduit or by pipe or substantial guard strips or by other approved means.

4. Where passing through floor, cable shall be protected

by rigid conduit or pipe passing through the floor and extending at least 6 inches above the floor.

e. When employed in concealed wiring, cable shall be installed as follows:

1. In buildings under construction, shall be secured between outlets with approved fastenings spaced at intervals not exceeding 4½ feet and shall be securely fastened within 12 inches of every outlet box or fitting.

2. In finished buildings where impracticable to support the cable as specified in the preceding paragraph, cable may be fished from outlet to outlet.

f. Cable, exposed or concealed, shall be run in continuous lengths, without joints, splices, or taps, from outlet box to outlet box, or other approved terminal fittings, and shall be secured thereto by means of approved devices which substantially close the openings. Approved outlet boxes or fittings as required by paragraph a of Order 1305.12 shall be installed at all outlets and switch points. Where grounding is required by Section 103 of this code the grounding conductor shall be connected to the boxes or fittings by approved means.

g. Bends in cable shall be so made and other handling shall be such that the protective coverings of the cables will not be injured, and no bend shall have a radius less than five times the diameter of the cable.

h. When cable is installed in conduit or in surface, or underfloor raceways, the provisions of Order 1305.03, 1305.04, and 1305.06 of this section shall apply as far as practicable.

i. When, in exposed or concealed wiring, cable is run through bored holes in studs, joists, or similar wood members, such holes shall be bored at the approximate center of such timbers or at least two inches from the nearest edge.

j. Cable in accessible attics or roof spaces shall be installed as follows:

1. When within seven feet of floor or joists, across the face of rafters or studding, or across the top or face of floor joists, cable shall be protected by substantial guard strips at least as high as the cable.

2. When carried along the sides of rafters, studs or floor joists, neither guard strips, nor running boards shall be required.

k. In unfinished cellars or basements, where cable is run at angles with the floor joists or timbers, it shall either be run through bored holes in joists or timbers or be attached

to the under side of running boards. When run parallel to joists or other timbers, the cable shall be attached to the side or face of such timbers.

l. Where assemblies not smaller than two No. 6 or three No. 8 wires are run at angles with floor joists, the protection specified in preceding paragraphs shall not be required.

m. In other places where subject to mechanical injury, cable shall be substantially protected by one of the above methods.

Order 1305.08. Electrical Metallic Tubing.

a. When electrical metallic tubing is employed for interior wiring systems or parts of such systems, the provisions of the following paragraphs of this section shall be observed.

b. The tubing, its couplings, elbows, bends, bushings, outlet fittings, etc., shall be of approved types. Connections between lengths of tubing and between tubing and any fitting shall provide adequate mechanical strength and electrical continuity and shall not employ threads in the wall of the tubing.

c. The tubing, and elbows and bends for use with the tubing, shall have a circular cross-section and shall have such a finish or treatment of outer surfaces as will provide a permanent approved means of readily distinguishing it, when installed, from rigid conduit.

d. Unless of a non-corrodible metal, all surfaces of tubing and fittings shall have approved coatings, such as baked enamel, zinc, cadmium or other approved metal finish.

e. Metallic tubing and fittings shall be of the following electrical trade sizes, as determined by the internal diameter of the tubing: No tubing smaller than ½", electrical trade size, shall be used except as provided for underplaster extensions in Order 1305.10 of this section and for inclosing the leads of fractional horsepower motors as permitted in paragraph a of Order 1310.03 of this code.

Nominal Electrical Trade Size	Approximate Actual Internal Diameter of Tubing
⅜ inch	0.493 inch
½	0.622
¾	0.824
1	1.049
1¼	1.38
1½	1.61
2	2.06

f. The designs of fittings approved for use with electrical metallic tubing shall provide a passageway free from burrs, shoulders or other projections which reduce the internal area of the passageway or are likely to cause abrasion of wires when being pulled in.

g. Elbows, offsets, bends or field bends in the tubing shall maintain the circular cross-section and shall not cause the inner face of such bends to be of a radius of less than six times the internal diameter of the tubing.

h. Electrical metallic tubing shall not be used for interior wiring systems of more than 600 volts, nor for conductors larger than No. 4.

i. Electrical metallic tubing may be used for open or concealed work where, during installation or afterwards, it will not be subject to severe mechanical injury nor to corrosive vapors. Tubing shall not be used in cinder concrete or fill unless protected on all sides by a layer of non-cinder concrete at least two inches thick. Threadless type couplings and connectors shall always be made up tight and where buried in concrete or masonry walls or where used in wet places shall be of the approved watertight type.

j. Electrical metallic tubing shall not have more than the equivalent of four-quarter-bends between consecutive outlets or outlets and fittings, not including bends at such outlets or fittings.

k. Electrical metallic tubing shall be installed as a complete system before the wires are pulled in. The system shall be continuous from approved fitting to approved fitting and shall be firmly secured in place. Pull wires, if used, shall not be installed until the tubing system is in place.

l. Approved outlet boxes or fittings, as required by paragraph a of Order 1305.12 of this section, shall be installed at all outlets and switch points.

m. Wires in electrical metallic tubing shall be of approved types that are suitable for the conditions prevailing at the particular location according to the following:

Where the temperature of the ambient-air exceeds 120° F. (49° C.) the wire shall be of the asbestos-covered (Type A) type or shall have slow-burning (Type SB) insulation; elsewhere rubber-covered wire (Type R) shall be used except that in permanently dry locations varnished-cloth insulated (Type VC) wire may be used.

All wires No. 6 and larger shall have stranded conductors. There shall be no splice or tap within the tubing proper.

n. Wires shall not be drawn into raceways of electrical metallic tubing until all mechanical work on the building which is liable to injure the wires has been completed, as far as possible.

o. When alternating current is to be employed, all conductors of a circuit shall be placed within one tube, except on circuits supplying vacuum and gas-tube lighting systems and signs and X-ray apparatus, and except as provided in Order 1305.10 of this section.

It is recommended that this course be followed in the case of direct current also, in order to avoid induction troubles, if a change is made to alternating current.

p. The number of wires (none larger than No. 4) contained in any run of electrical metallic tubing shall not exceed that given in tables 1 to 4, Order 1305.03 of this section. The maximum size of tubing which may be used with any number or combination of wires shall be the 2-inch electrical trade size.

q. Wires of different systems shall not occupy the same tubing, outlet box, junction box, fitting, or cabinet. (See paragraph p of Order 1305.12.)

r. Wires in vertical runs of electrical metallic tubing exceeding 100 feet shall be supported as is specified for wires in rigid conduits in paragraphs r and s of Order 1305.03 of this section.

s. For tubing installed in concrete or other masonry in direct contact with moist earth, or in other permanently moist locations where subject to the condensation of moisture, the conductors shall be of the lead covered type, or of other type specially approved for this purpose.

t. Electrical metallic tubing shall be grounded as is specified for other metallic raceway wiring methods in Section 103 of this code.

Order 1305.09. Cast-in-Place Raceways.

a. Wires may be installed in raceways cast-in-place in floor slabs, walls and ceilings, or other structural units of Portland cement concrete or of similar material when the provisions of the following paragraphs of this section shall be observed.

b. The installer shall satisfy the proper authorities that suitable allowance has been made for the raceway in determining the strength and fire-resistive value of the floor slab or other structural unit.

c. Cast-in-place raceways shall terminate in fittings especially approved for use with them at all junction, outlet and switch points. In general, the appropriate provisions of Section 130.7 and of Order 1305.12 of this section shall apply to the construction and installation of such fittings.

d. Wires used with cast-in-place raceways shall be Code standard and of types specified for conduit work according to paragraph (l) of Order 1305.03 of this Section.

e. The further provisions of Order 1305.03 with respect to time of drawing in wires, wires of different systems, numbers and sizes of wires in a single raceway and their support in vertical raceways, etc., as given in paragraphs m, n, and p to s inclusive of Order 1305.03 shall apply.

Order 1305.10. Underplaster Extensions. (Concealed)

a. Lighting Branch Circuits, Combination Lighting and Appliance Branch Circuits, 15-ampere and Appliance Branch Circuits may be installed as underplaster or concealed extensions of existing similar branch circuits in buildings of fire-resistive construction when the provisions of the following paragraphs of this order are observed.

b. Such extensions shall be run in rigid or flexible conduit, armored cable (subject to the provisions of paragraph c, Order 1305.05), 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 wires only conduit or tubing having not less than $\frac{5}{16}''$ inside diameter or single-conductor armored cable may be used.

c. Such extensions shall be laid on the face of masonry or other material of which the walls and ceilings are composed and shall then be buried in the plaster finish. Except when run in standard sizes of rigid conduit or electrical metallic tubing, such extensions shall not be run beyond the floor where they originate.

d. The methods of installation for such extensions shall be as given in the appropriate orders of this section for the wiring method employed, except that for all of the recognized methods, as in paragraph b of this order, the conductors of a circuit even when alternating current is to be employed need not be placed within one raceway inclosure.

Order 1305.11. Wireways and Busways.

a. Approved types of wireways and busways and fittings may be used if installed in exposed dry locations in industrial premises for circuits of not more than 600 volts. They shall not be placed in hoistways nor where they will be subject to severe mechanical injury, nor where corrosive vapors are present, nor in hazardous locations. Busways may also be used as risers and feeders in office buildings of fire-resistive construction.

b. Wireways and busways shall be of substantial construction and all surfaces, both interior and exterior, shall be suitably protected from corrosion.

c. Wireways, busways and their fittings shall be of such designs and so installed that adequate electrical and mechanical continuity throughout the systems will be secured. Wireways and their fittings shall be designed so as to protect the contained wires from abrasion.

d. Runs of wireways shall be continuous throughout their entire lengths and shall be installed as complete systems without wires. Wires shall not be laid in until all the mechanical work on the building liable to injure the wires has been completed as far as possible. Wireways and busways may extend transversely through dry walls or partitions if in unbroken lengths where passing through. Wireways and busways shall be securely supported at least every five feet. Dead ends shall be closed by approved fittings.

e. Conductors used in wireways shall be approved rubber-covered wires, Type R, or shall have varnished-cloth insulation, Type VC wire, except that slow-burning wire, Type SB, or asbestos-covered wire, Type A, shall be used where the ambient-air temperature at the wire as installed will exceed 120° F. (49° C.). On branch or feeder circuits splices or taps made and insulated by approved methods may be located within the wireway when they are accessible by means of hinged covers or at pull boxes; except that on motor circuits having conductors larger than No. 6, splices or taps may be made only when special permission has been obtained from the authority enforcing the code.

f. Wireways shall not contain more than 30 conductors, unless special permission is obtained for the use of a larger number, or unless all conductors in excess of 30 are for signaling circuits or are control wires between a motor and its starter and used only for starting duty. In any case, the following provisions shall be observed:

1. No conductor larger than 500,000 C.M. shall be used.

2. The sum of the cross-sectional areas of all contained conductors shall not exceed 20 per cent of the interior cross-sectional area of the wireway.

3. The temperature of rubber-covered wires in a wireway shall at no time exceed 120° F. (49° C.).

g. Rigid or flexible conduits, electrical metallic tubing, surface metal raceways or armored cable shall be used in extensions from wireways or from busways and shall be connected to the wireway or busway in a manner that is approved for the material employed as specified in other orders of this section.

h. Wires of different systems shall not occupy the same wireway unless separated from each other by barriers in accordance with the provisions of paragraph p of Order 1305.12.

i. When alternating current is to be employed, all conductors of a circuit shall be placed within the same wireway in accordance with the provisions of paragraph o of Order 1305.03.

j. Busways shall be marked with the current rating for which they are designed. Wireways and busways shall be marked so that their manufacturer's name or trade name can be determined after the installation is made.

k. Plug-in connections or other devices for tapping off branch lines from busways shall be of approved types containing the necessary automatic overload protective devices required for the branch circuit.

l. Wireways and busways shall be grounded as prescribed in Section 103 of this code, and when grounded shall have bonding jumpers at expansion joints or telescoping sections.

Order 1305.12. Installation of Boxes, Cabinets, Outlet and Terminal Fittings and Auxiliary-Gutters.

See Section 130.7 for construction details.

a. At each outlet, switch, or junction point of conduit, surface metal raceway, armored cable, electrical metallic tubing, or non-metallic sheathed cable, and at each outlet and switch point of concealed knob-and-tube work, an approved box shall be installed. At least six inches of free conductor shall be left at each outlet for the making up of joints or the connection of fixtures except where conductors are intended to loop through sockets, receptacles and similar devices without joints.

b. In completed installations, the box shall be provided with a cover, unless a fixture canopy is present. When a fixture canopy is used in lieu of a cover and the wall or ceiling finish is of combustible material, a continuous metal to metal (or equivalent) fit shall be secured between the edge of the box and the canopy.

c. Outlet boxes for concealed work shall have an internal depth of at least one and one-half inches, except that where the installation of such a box will result in injury to the building structure or is impracticable, a box of not less than one-half inch internal depth may be installed.

d. An approved outlet or terminal fitting may be used in lieu of the box required by paragraph a of this order at ends of conduit, armored cable, surface metal raceway and electrical metallic tubing from which wires are run without splice, tap or joint within the fitting, to appliances or to knob-and-tube wiring. The fitting shall provide a separately bushed hole for each wire. It need not be accessible when in concealed knob-and-tube work. Such fittings shall not be used at outlets for fixtures. An approved insulating bushing may be used in lieu of a box at ends of conduit or electrical metallic tubing where wires leave the conduit or tubing behind a switchboard or where more than eight wires leave the conduit or tubing at control apparatus or in similar locations, in which case the wires shall be bunched, taped, and painted with insulating paint.

e. In new work approved metal supports shall be used for boxes and fittings which are not secured to a stud, joist or similar fixed structural unit except that a wooden board at least seven-eighths inch in thickness may be used for support if rigidly secured to such structural units. Lath, of wood, metal, or composition, shall not be considered a structural unit.

f. Covers of outlet boxes and outlet fittings having holes through which flexible cord pendants pass, shall be provided with approved bushings or shall have smooth, well-rounded surfaces on which the cord may bear. Where wires, other than flexible cord, 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.

g. Boxes, cabinets and fittings shall be securely fastened in place. Boxes and fittings not over 100 cubic inches in size and which are attached to firmly secured, exposed race-

way by threading or other connection approved for the purpose are considered as so fastened.

h. Outlet boxes used where gas outlets are present shall be so fastened to the gas pipes as to be mechanically secure.

i. Junction boxes shall be so installed that the wiring contained in them may be rendered accessible without removing any part of the building.

j. Boxes, cabinets and fittings when installed in walls or ceilings shall be so installed that the front edge of the fitting will not set back of the finished surface more than one-quarter inch. On wooden or combustible walls or ceilings, the front edges of the fitting shall be flush with the finished surface, or project therefrom. 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 fitting. Outlet boxes newly installed as additions to existing concealed knob-and-tube work may be mounted directly upon existing plaster surfaces if securely fastened in place. These requirements do not apply to walls or ceilings composed of concrete, tile or other non-combustible material.

k. In moist places, boxes, cabinets, and fittings shall be so placed or equipped as to prevent moisture from entering and accumulating within the device.

l. Openings in boxes, cabinets and fittings shall be equipped, either separately or as a part of the fitting, with couplings or bushings which will serve to secure the conduit, electrical metallic tubing, raceway, armored cable, nonmetallic sheathed cable, or flexible tubing to the fitting and, including open wires, shall close the opening adequately and at the same time protect the wires from abrasion. Where a wood cabinet is used each opening shall be equipped with a non-combustible, non-absorptive insulating bushing which shall fit securely in the opening and be so closed by the wire, and tape if necessary, as to fit tightly. In dry places where open work or knob-and-tube work is used, approved flexible tubing may be employed as an insulating bushing if it extends from the last insulating support and is firmly secured in place.

m. Unused openings in boxes, cabinets and fittings shall be effectively closed by metal plugs or plates affording protection substantially equivalent to that of the wall of the fitting.

n. Auxiliary-gutters, metal boxes, cabinets and fittings used with conduit, electrical metallic tubing, armored cable or metal raceway, shall be grounded when and in the manner specified in Section 103 of this Code.

o. In making a surface 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.

p. Wires of different systems shall not occupy the same box, cabinet, or auxiliary gutters unless a barrier of sheet steel not less than No. 16 U. S. gauge or its equivalent, or of suitable insulating material is used to divide this space in order to separate the wires of different systems. Such a barrier shall be rigidly fastened to the box or cabinet unless a device approved as assuring positive separation of the wires in the box or cabinet is to be used. Special permission shall be obtained where it is necessary to vary from the foregoing to accomplish the desired result from the use of a double throw switch as in the case of some emergency lighting systems, or from the use of remote control devices and their circuit conductors.

Different systems are those which derive their supply from: 1. Different sources of current. 2. Transformers connected to separate primary circuits, or 3. Transformers having different maximum secondary voltages.

q. The number of wires, running through or terminating in an outlet or junction box, shall be limited according to the free space within the box and the sizes of the wires as follows:

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

For the patterns of boxes in common use and when no fittings such as fixture studs or hickeys are located within the box the foregoing will generally permit:

Box Dimensions	Maximum Number of Wires No. 14	12	10	8
1½ x 3¼ Octagonal or Round	8	6	4	--
1½ x 4 Octagonal or Round	10	8	6	4
1½ x 4 Square	12	10	8	6
1½ x 4 11/16 Square	16	12	10	8
2⅛ x 4 11/16 Square	20	16	12	10

The above limitations are not intended to be applied to terminal housings supplied with motors nor to types of boxes or fittings with-

out knockouts and having hubs or recessed ports for terminal bushings and locknuts.

r. Cabinets or cutout boxes housing lighting branch circuit panel-boards or cutout bases shall not contain the conductors of more than 42 circuits where one automatic overcurrent protective device per circuit is used or more than 20 circuits where two automatic overcurrent protective devices per circuit are used. For the purpose of this paragraph, sections of cabinets and cutout boxes completely separated by unpierced barriers of non-combustible material shall be considered as separate cabinets or boxes.

s. *Auxiliary Gutters.*

1. Auxiliary gutters, used to supplement wiring spaces at meter centers, distribution centers, switchboards and similar points of interior wiring systems may inclose wires and cables or busbars, but shall not be used to inclose switches, overcurrent protective devices or other appliances or apparatus. An auxiliary gutter shall not extend a greater distance than 20 feet beyond the equipment which it supplements except when an approved wireway or busway is used for the purpose.

2. Covers shall be securely fastened to the gutter in an approved manner; and the gutter shall be supported at intervals not exceeding five feet throughout its entire length.

3. 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.

4. The sum of the cross-sectional areas of all wires, including splices and taps, at any cross-section of a gutter, shall not exceed 20 per cent of the cross-sectional area of the gutter at that point, and no single compartment of a gutter shall contain more than 30 wires at any cross-section.

5. Busbars 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 not be less than two inches, nor less than one inch when the parts are held free in air. A minimum spacing of one inch shall be secured between bare current-carrying metal parts and any metal surface. Adequate provision shall be made for expansion and contraction of busbars.

6. Taps from busbars shall leave the gutter opposite their terminal connections and conductors shall not be brought in contact with uninsulated current-carrying parts of opposite polarity.

7. Bare copper busbars in auxiliary gutters shall not be permitted to carry continuously currents greater than 1000 amperes per square inch cross-section of the busbars.

8. Unfused tap connections from cables or buses shall comply with the provisions of paragraph d of Order 1308.06 of this code.

9. All taps shall be suitably identified at the gutter as to the circuit or equipment which they supply.

10. Gutters shall be grounded as prescribed in Section 103 of this code.

Order 1305.13. Insulation Resistance.

a. A completed installation shall have a resistance between conductors, and between all conductors and ground, not less than:

Up to 5 amperes	4,000,000 ohms.
Up to 10 amperes	2,000,000 ohms.
Up to 25 amperes	800,000 ohms.
Up to 50 amperes	400,000 ohms.
Up to 100 amperes	200,000 ohms.
Up to 200 amperes	100,000 ohms.
Up to 400 amperes	50,000 ohms.
Up to 800 amperes	25,000 ohms.
Up to 1600 amperes	12,000 ohms.

b. The above values shall be determined with all cutouts, and safety devices in place. If lamp sockets, receptacles, fixtures and other appliances are also connected, the minimum resistance required shall be one-half that specified in the table.

Order 1305.14. Wooden Raceways.

Wooden raceways shall not be used except when specifically permitted or required by the authority enforcing this code.

Order 1305.15. Bare Bus-Bars and Risers.

a. Conductors serving as main risers or as feeders in buildings of fire-resistive construction may be run bare without insulating coverings when the following precautions are observed, and provided special permission has been secured for each such installation.

b. The following general limitations and precautions shall be observed. In addition, the authority enforcing this Code may require other safeguards in view of local or special circumstances that may be encountered in a particular installation.

1. The circuit shall not operate at more than 600 volts between any two conductors or between any conductor and the ground.

2. The conductors shall be placed in a chase, channel or shaft which shall be so located or guarded that the conductors are not accessible to other than qualified persons.

3. The premises shall not constitute a hazardous location as elsewhere defined in this Code and shall be generally free of corrosive or damp atmospheric or other conditions.

4. When floors are pierced suitable cut-offs against vertical travel of fire shall be provided.

5. The mechanical and electrical features of the installation, including conductor supports, shall evidence appropriate engineering consideration of the various operating and maintenance conditions likely to be encountered.

(See Appendix H.)

Order 1305.16. Non-Metallic Surface Extensions.

a. One or more 2-wire assemblies approved for the purpose may be used from existing convenience or receptacle outlets as extensions to a 15-ampere and appliance branch circuits but only to supply additional convenience or receptacle outlets in exposed dry locations in residence or office occupancies and not in basements, attics or roof spaces.

Receptacle outlets are defined in Section 132.0. These devices are commonly known as "convenience outlets".

b. Supply connections of such extensions to such existing outlets shall be by fittings approved for the purpose.

c. Such assemblies shall be attached only to the surface of interior woodwork or plaster finish. They shall not be installed as concealed wiring or run through floors or partitions nor where subject to moisture or corrosive vapors. They shall not be installed in contact with any piping, metal work or other conductive material (metal plates on outlets excepted).

d. Such extensions shall not be supplied from circuits of more than 150 volts. The sum of the outlets connected to a supplying branch circuit, including those previously installed and those of the extension, shall conform with the limitations prescribed in paragraph a–3 of Order 1320.05 of Section 132.0.

e. Extensions may be run in any direction (excepting upon floors) from the supplying outlet. They shall not extend beyond the room in which they originate. When on side walls they shall be at least two inches above the floor.

f. Every extension shall be of a continuous unbroken length of the assembly without splices or taps and without exposed conductors between fittings.

g. Assemblies shall be secured to the surface wired over by approved means and at intervals of not more than six inches. There shall be at least one such fastening between all outlets supplied by the assembly. When, however, the connection to the supplying outlet is by means of an attachment plug the first fastening may be placed up to 12 inches from the plug.

h. Receptacles and other fittings used with extension assemblies shall be of types approved for the purpose and shall be secured to the surface wired over by approved means. Angle bends in runs of such assemblies which reduce the normal spacing between conductors of the assembly shall be covered with an approved cap which shall be securely fastened to the surface wired over. The run of a surface extension assembly shall terminate in an approved fitting which shall cover the ends of the assembly conductors.

SECTION 130.6. CONDUCTORS

Order 1306.01. Marking.

a. Wires, cables and cords of all kinds except weatherproof 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 pressure or 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.

Order 1306.02. Rubber-covered Wires.

For installation rules, See Section 130.5 of this Code.

a. Classification.

R	Rubber-covered for voltages	0– 600
R10		601–1000
R20		1001–2000
R30		2001–3000
R40		3001–4000
R50		4001–5000
AC	A cable having two or more rubber-insulated, fibrous-covered conductors twisted together.	
RD	A "twin wire," having two rubber insulated fibrous-covered conductors laid parallel under an outer fibrous cover.	

The addition of the suffix L to any of the above type designations indicates that an outer covering of lead has been applied.

b. All approved rubber-covered wires shall be examined and tested at the factory and shall be labeled before shipment.

c. Conductors shall be covered for their entire length with a properly applied and properly vulcanized rubber compound. This rubber covering shall be of the nominal thickness given in the following table, the requirements of which vary according to the sizes of conductors and the maximum working pressure.

Table of Thicknesses of Rubber Insulation for Rubber-covered Wires and Cables in 64th Inches

Conductor Size Awg or 1000 C. M.	Voltage					
	0–600	601–1000	1001–2000	2001–3000	3001–4000	4001–5000
14–9	3	4	5	7	9	10
8	4	4	5	7	9	10
7–2	4	5	6	8	9	10
1–4/0	5	6	7	8	9	10
225–500	6	7	8	9	10	11
525–1000	7	8	8	9	10	11
Over 1000	8	9	9	10	11	12

d. Single conductor Type R wires, unless provided with a lead sheath, shall be covered for their entire length with a braid which is both flame-retarding and moisture-resisting.

e. Lead coverings may be applied to single or multiple conductors. Lead-covered multiple-conductor cable with more than two conductors shall, in all cases, have the conductors helically laid. In all cases, the individual conductors of lead-covered cable shall have a fibrous covering, and except for two-conductor cables with conductors parallel, there shall be a fibrous covering over multiple conductors.

f. Single rubber-covered wires No. 6 and smaller intended for use as identified conductors of circuits shall have the outer covering finished to show a white or natural gray color. Twin and twisted pair wires and three-conductor cables shall have one conductor, and four-conductor cables shall have at least one conductor identified in this manner. The coverings of the other conductors shall be finished to show solid colors other than white or natural gray.

Note: 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 requirements of this paragraph.

Order 1306.03. Varnished-Cambric-Covered Wire. Type VC.

For installation see Section 130.5. This wire is not intended for use where moisture exists.

a. Varnished cambric shall be applied in layers and filled as may be specified, and shall have at least one fibrous covering.

b. The thickness of the varnished cambric and filler shall be not less than those given in the following table:

Tables of Thicknesses of Varnished Cambric and Filler in 64th Inches.

TABLE A—SINGLE-CONDUCTOR CABLE

Conductor Size Awg or 1000 C. M.	Voltage					
	0–600	601–1000	1001–2000	2001–3000	3001–4000	4001–5000
14–8	3	4	5*	7*	8*	10*
7–2	4	4	5	7	8	10
1–4/0	5	5	6	7	8	10
225–500	6	6	6	8	9	11
525–1000	7	7	7	8	9	11
Over 1000	8	8	8	9	10	11

* Thickness specified for No. 8 only.

TABLE B—MULTIPLE-CONDUCTOR CABLE

Conductor Size Awg or 1000 C. M.	Voltage											
	0–600		601–1000		1001–2000		2001–3000		3001–4000		4001–5000	
	C	B	C	B	C	B	C	B	C	B	C	B
14–8	3	0	4	0	*5	0	*5	*2	*6	*3	*6	*4
7–2	4	0	4	0	5	0	5	2	6	3	6	4
1–4/0	5	0	5	0	6	0	6	2	6	3	6	4
225–500	6	0	6	0	6	0	6	2	6	3	7	4
525–1000	6	2	6	2	6	2	6	3	6	4	7	4
Over 1000	7	2	7	2	7	2	7	3	7	4	7	5

* Thickness specified for No. 8 only.

The thicknesses given in columns headed "C" are for the insulation on the individual conductors.

Those given in the columns headed "B" are for the thickness of the over-all belt of insulation.

c. No individual conductor, whether solid or stranded, shall be less than No. 14 gage. Conductors may be either plain or tinned.

Order 1306.04. Asbestos-Covered Wire. Type A.

For asbestos covered fixture wire see Order 1306.08.
For installation see Section 130.5.

This wire is especially useful in hot, dry places where ordinary coverings would perish, and where wires are bunched as on the back of a large switchboard or in a wire tower, so that the accumulations of rubber covering would result in an objectionable large mass of highly flammable material. It is not suitable for outside work or where moisture exists.

a. Asbestos covered wire shall be of approved type.

Order 1306.05. Slow-Burning Wire, Type SB.

For slow-burning fixture wire see Order 1306.08. For installation see Section 130.5 and Orders 1314.02 and 1315.05.

This wire is especially useful in hot, dry places where ordinary covering would perish, and where wires are bunched as on the back of a large switchboard or in a wire tower, so that the accumulations of rubber covering would result in an objectionable large mass of highly flammable material. It is not suitable for outside work or where moisture exists.

a. Slow-burning conductors especially designed and approved for use in fixtures as prescribed in Order 1306.08 of this Code need not necessarily comply with the requirements of paragraphs b and c of this section.

b. The insulation shall consist of three braids of cotton or other thread, all the interstices of which shall be filled with material having fire-resisting and insulating properties. Its surface shall be finished smooth and hard.

c. The thickness of the completed covering shall be not less than that prescribed in Order 1306.02 of this Code for the rubber insulation of 0–600 volt rubber covered wires.

Order 1306.06. Slow-Burning Weatherproof Wire, Type SBW.

For installation see Section 130.5.
This wire is not suitable for outside work or where moisture exists.

a. The covering shall consist of two layers, one to be weather-resistive, and the other fire-retarding. The fire-retarding coating shall be on the outside and shall comprise about six-tenths of the total thickness of the wall.

b. The thickness of the completed covering shall be not less than that prescribed in Order 1306.02 of this Code for rubber covering of 0–600 volt rubber-covered wires.

Order 1306.07. Weatherproof Wire, Type WP.

For installation see Section 130.5.
This wire is for use outdoors and elsewhere where moisture is certain, or corrosive vapors are present, and where fire-retardant qualities are not necessary.

a. The covering shall consist of at least three braids, or their equivalent, all of which shall be thoroughly saturated with a dense moisture-proof compound.

Order 1306.08. Fixture Wire.

For installation see Section 131.4.

a. Fixture wires shall be of the several types given in the following:

Type AF asbestos-covered, heat-resisting fixture wire.

Type CF cotton-covered heat resisting fixture wire.

Type RF—64 rubber-covered fixture wire—1/64 inch insulation—solid or stranded.

Type RF–32 rubber-covered fixture wire—1/32 inch insulation—solid or stranded.

Type RF rubber-covered fixture wire—3/64 inch insulation—solid or stranded.

Type FF–64 rubber-covered fixture wire—1/64 inch insulation—flexible stranding.

Type FF–32 rubber-covered fixture wire—1/32 inch insulation—flexible stranding.

Type FF rubber-covered fixture wire—3/64 inch insulation—flexible stranding.

b. If stranded conductor is used, the strands shall be braided, laid up concentrically or rope stranded or shall be covered with a tight close wind of fine cotton.

c. Type AF fixture wire shall have an approved asbestos covering with or without cotton or silk braid.

d. The rubber covering of Types RF–64, RF–32, RF, FF–64, FF–32 and FF fixture wire shall consist of properly applied and properly vulcanized rubber compound. The thickness of this rubber covering shall be not less than 1/64 inch for No. 18 wire, not less than 1/32 inch for No. 16 wire, and not less than 3/64 inch for No. 14 wire. Coverings shall be of braided cotton or silk or of other approved material, and shall be sufficiently tenacious to withstand abrasion when being pulled into fixtures.

e. The coverings of type CF fixture wire shall consist of two braids of cotton or of other thread, all the interstices of which shall be filled with material having fire-resisting and insulating properties. Its surface shall be finished smooth and hard. Outer coverings of braided cotton or silk may be provided.

Order 1306.09. Flexible Cords.

For installation see Order 1306.13 of this Section.

a. All approved rubber-covered flexible cords shall be examined and tested at the factory and shall be labeled before shipment.

b. The rubber covering, except for asbestos-covered tinsel cord (Type AT) and heater cord (Type H), shall consist of a properly applied and properly vulcanized rubber compound. The nominal thickness of the rubber covering shall be as given in the following table:

Am. Wire Gauge No.	Thickness Inches
18 and 16	1/32
14 to 8	3/64

Exceptions: For Types AT, CT, P–64, PO–64, PWP–64 and H the rubber covering shall be 1/64 inch in thickness.

c. Each stranded conductor shall, except for heat-resisting cord (Types AFC, AFPO, AFPD, AFS, AFSJ, CFC, CFPO and CFPD), be covered with a tight close wind of cotton, or some other method shall be employed to prevent a broken strand puncturing the rubber covering.

d. Cords of the several types shall conform to the descriptions of the table following. The cords listed in the

Use			Type Letter	Trade Name	Braid on Each Conductor	Filler	Outer Cover	
							Kind	No.
In Dry Places	Attached to a Device	Not Subject to Hard Usage	AT**	Tinsel Cord	Cotton	None	Cotton or Silk	1
			CT**					
	Pendant		AFC	Heat-Resisting Cord	Cotton or Silk	None	None	
			AFPO		None	None	Cotton or Silk	1
			AFPD		None	None	Cotton or Silk	1
			CFC		Cotton or Silk	None	None	—
			CFPD		None	None	Cotton or Silk	1
			CFPO		None	None	Cotton or Silk	1
For use only with portable lamp fixtures, portable radio receiving appliances, portable clocks and similar appliances which are not liable to be moved frequently and when appearance is a consideration.			PO-64	Parallel Cord	Cotton	None	Cotton or Silk	1
			POSJ	All Rubber Parallel Cord	None	Special Rubber Jacket	None	None
	Pendant and Portable	Not Subject to Hard Usage	PO-32	Parallel Cord	Cotton	None	Cotton or Silk	1
			PO					
			C	Lamp Cord	Cotton or Silk	None	None	—
			PD	Twisted Portable	Cotton	None	Cotton or Silk	1
			P-64					
		Where Subject to Hard Usage	P-32	Reinforced Cord	Cotton	Rubber Jacket	Cotton or Silk	1
			P					
			CA	Armored Cord	Cotton	None	Standard Armor	1
			PA	Armored Reinforced Cord	Cotton	Rubber Jacket	Cotton & Standard Armor	2
In Damp Places	Pendant	Where Not Subject to Hard Usage	PWP64	Moisture Proof Reinforced Cord	Cotton	Rubber Jacket	Cotton Moisture-proofed	1
			PWP32					
			PWP					
In Damp Places	Pendant or Portable	Subject to Hard Usage	K*	Braided Heavy Duty Cord	Cotton	Jute, Cotton Sisal, Hemp, Twisted Paper	Cotton Moisture-proofed	2[0]
			PAWP	Moisture Proof Armored Reinforced Cord	Cotton	Rubber Jacket	Cotton Moisture-proofed Standard Armor	2[0]
			SJ	Jun'r Hard Service Cord	None	Special Rubber Jacket	None	—
		Subject Ex. Hard Usage	S‡	Hard Service Cord	None	Special Rubber Jacket	None	—
Elevator Lighting and Control			E	Elevator Cable	Cotton	Rubber Jacket	Cotton Moisture-proofed	1
						None	Cotton Outer One Moisture-proofed	3[0]
Portable Heaters			AF	Rubber Jacketed Heat Resisting Cord	None	Special Rubber Jacket	None	—
			AFSJ					
			HC	Heat Resisting Cord	Cotton or Silk	None	None	—
			HPD		None		Cotton or Silk	1

* Type K is suitable for use on theatre stages.

** Types AT and CT 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. Type AT is for use only on heating appliances.

‡ Type S is suitable for use on theater stages, for elevator lighting and control and in garages and elsewhere wherever flexible cords having rubber insulation are permitted by this Code.

° Rubber-filled or varnished-cambric tapes may be substituted for the inner braids.

Except for types PO-64, POSJ, PO-32 and PO, individual conductors are twisted together.

table, except Types AT and CT, are recognized in sizes No. 18 and larger, except that Types PO–64, P–64 and PWP–64 are recognized in No. 18 only. Types PO–32, P–32 and PWP–32 in No. 18 and 16 only, and Type E in No. 16 and larger.

e. Other types of flexible cords than those listed in the table shall be submitted for special investigation and shall be approved before being used. The conductors of such cords shall not be smaller than No. 18 unless of Type AT or CT.

f. One conductor of flexible cords shall have a continuous identifying marker readily distinguishing it from the other conductors. This marker shall consist of a braid finished to show a white or natural gray color, the braid on the other conductor or conductors being finished to show a readily distinguishable solid color or colors; or of a tracer in the braid of any color contrasting with that of the braid and no tracer in the braid of the other conductor or conductors; or in the case of cords having no individual braids, the insulation of one conductor shall be of a white or natural gray color and the insulation of the other conductor or conductors shall be of a readily distinguishable color or colors. No tracer thread 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 and PO cords having the braid 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.

Order 1306.10. Armored Cable.

For installation, see Order 1305.05.
For armored cord, see Order 1306.09.

a. The conductors shall comply with the requirements for rubber-covered wires. The individual conductors shall be covered for their entire length with a braid which is both flame-retarding and moisture-resisting.

b. 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.

Order 1306.11. Non-Metallic Sheathed Cable.

For installation see Order 1305.07.

a. The conductors shall comply with the requirements for rubber-covered wires, except that no braid need be provided directly over the rubber covering.

b. Cable shall be of approved type, in sizes 14 to 4, inclusive, and in two or three-wire assemblies and in addition may have an approved size of non-insulated copper conductor laid in next to the insulated conductor for grounding purposes.

c. The cable shall have a continuous distinctive marker so that the maker may be readily identified.

Order 1306.12. Carrying Capacity of Conductors.

a. The following tables give the allowable continuous current-carrying capacities of copper wires and cables of 98 per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers.

See Section 132.0 for Demand Calculations for Feeder Sizes.

TABLE 1

Allowable Carrying Capacities of Wires

Gage No.	Diameter of Solid Wires in Mils	Area in Circular Mils	Column A Rubber Insulation Amperes	Column B Varnished Cambric Insulation Amperes	Column C Other* Insulation Amperes
18	40.3	1,624	3	----------	5†
16	50.8	2,583	6	----------	10†
14	64.1	4,107	15	18	20
12	80.8	6,530	20	25	25
10	101.9	10,380	25	30	30
8	128.5	16,510	35	40	50
6	162.0	26,250	50	60	70
5	181.9	33,100	55	65	80
4	204.3	41,740	70	85	90
3	229.4	52,630	80	95	100
2	257.6	66,370	90	110	125
1	289.3	83,690	100	120	150
0	325.	105,500	125	150	200
00	364.8	135,100	150	180	225
000	409.6	167,800	175	210	275
0000	460.	200,000	200	240	300
		211,600	225	270	325
		250,000	250	300	350
		300,000	275	330	400
		350,000	300	360	450
		400,000	325	390	500
		500,000	400	480	600
		600,000	450	540	680
		700,000	500	600	760
		800,000	550	660	840
		900,000	600	720	920
		1,000,000	650	780	1,000
		1,100,000	690	830	1,080
		1,200,000	730	880	1,150
		1,300,000	770	920	1,220
		1,400,000	810	970	1,290
		1,500,000	850	1,020	1,360
		1,600,000	890	1,070	1,430
		1,700,000	930	1,120	1,490
		1,800,000	970	1,160	1,550
		1,900,000	1,010	1,210	1,610
		2,000,000	1,050	1,260	1,670

1 Mil = 0.001 inch.
* Applicable to bare conductors also, pending outcome of investigations.
† The allowable carrying capacities of No. 18 and No. 16 are 10 and 15 amperes, respectively, when in cords for portable heaters, Types HC and HPD.

b. For aluminum wire the allowable carrying capacities shall be taken as 84 per cent of those given in the table for the respective sizes of copper wire with the same kind of covering.

c. Conductors, whether solid or stranded, shall not be of smaller size than No. 14, except that conductors of sizes Nos. 18 and 16 may be used for flexible cords, for fixture wires, for control and signal circuits, and with fractional horsepower motors as provided in paragraph a of Order 1310.03 of Section 131.0; and conductors of sizes smaller than No. 18 may be used in cords of Types CT and AT.

d. Conductors may be placed in multiple only by permission of the authority enforcing this Code.

e. Varnished cambric insulated wires smaller than No. 6 shall be used only by permission of the authority enforcing this Code.

Order 1306.13. Use of Flexible Cords.

a. Flexible cord shall be used only for pendants, wiring of fixtures and portable and movable equipment.

b. For all portable work and pendants which are liable to be moved about sufficiently to come in contact with surrounding objects, flexible wires and cables especially designed to withstand this severe service shall be used; for portable devices, or pendants which are not liable to be so located or to be moved about sufficiently to cause abrasion of the insulation, approved flexible cord of Type C may be used.

c. Unless provided with approved metal armor, flexible cords shall not be used in show windows or in show cases, except that approved portable cord may be used for the purpose of supplying current to portable lamps and other devices for exhibition purposes, and flexible cord may be used for chain fixtures.

d. Flexible cords shall be protected by approved insulating bushings where they enter sockets.

e. Flexible cords shall be so connected to all fittings that the strain will be taken from the joints and terminal screws by a knot in the cord, winding with tape, a special fitting for the purpose, or other suitable means. (See Order 1314.05g)

f. Flexible cords shall, where passing through covers of outlet boxes, be protected by approved bushings especially designed for this purpose, or the cover shall be provided with a smooth, well-rounded surface on which the cord will

bear. So-called hard-rubber or composition bushings shall not be used.

g. Flexible cords used where the voltage between any two conductors exceeds 300 volts but does not exceed 600 volts shall have insulation on the individual conductors at least 3/64 inch in thickness for conductor sizes No. 8 and less, except that Type S cord may be used when the voltage between any two conductors does not exceed 600 volts.

h. Flexible cords not smaller than No. 18 gauge, and flexible cords of smaller sizes approved for use with specific devices, may be attached to circuits fused at not over 15 amperes for not exceeding 150 volts and not over 10 amperes for not exceeding 300 volts, and shall be considered as protected by such circuit fuses. Flexible cords No. 18, or larger if required by column 1 of the table, Order 1306.12, may be approved for use with specific devices on the appliance branch-circuits described in Order 1320.06 of Section 132.0.

i. No wire smaller than No. 18 shall be used for fixture work or flexible cords, except as approved for specific devices. See also paragraph c of Order 1306.12.

j. Flexible cord shall not be hung on or fastened with or come in contact with nails, staples, hooks, pipes, machinery or other metal supports.

k. Portable Electric Hand Lamps. Portable electric hand lamps shall be equipped with keyless sockets of non-combustible, non-absorbent insulating material, large handles of non-absorbent insulating material, basket guards, reflectors and proper cords. (See d above)

SECTION 130.7. BOXES, CABINETS, AND OUTLET AND TERMINAL FITTINGS.

Order 1307.01. Construction of Outlet, Switch, Junction and Pull Boxes and Outlet and Terminal Fittings.

a. Boxes and fittings unless of corrosion resistive metal shall be well galvanized, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

Note: 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. 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 U. S. Standard Gauge (0.078 in.) in thickness, or if of cast metal shall have a wall thickness of not less than

1/8 inch, except that if of malleable iron, they shall have a wall thickness of not less than 3/32 inch.

c. 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 inclosing joints in wires or to facilitate the drawing in of wires or cables. They are not intended to inclose switches, cutouts or other control devices.

d. 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 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.

e. Covers of outlet boxes and outlet fittings having holes through which flexible cord pendants may pass, shall be provided with approved bushings or shall have smooth, well-rounded surfaces, upon which the cord may bear. Where wires 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.

f. Flush switch and receptacle plates, if of metal, shall be not less than 0.04 inch in thickness.

g. A fixture stud which is not an integral part of the outlet box shall be composed of steel, malleable iron or other approved material.

h. Outlet boxes intended for use where gas outlets are present shall be so designed that they may be securely fastened to the gas pipes in an approved manner.

i. Boxes and fittings intended for outdoor use shall be of approved weatherproof type.

j. Boxes used to inclose flush devices shall be of such design that the devices will be completely inclosed on back and sides, and that substantial support for the devices will be provided. Screws for supporting the box shall not be used for attachment of the device contained therein. Floor-outlet boxes shall be so designed as to protect receptacles and attachment plugs from mechanical injury and moisture.

Order 1307.02. Construction of Cabinets and Cutout Boxes.

a. 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.

Note: 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. 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 U. S. Standard Gauge (0.063 inch) in thickness.

c. Wooden and (or) composition cabinets, whether for flush or surface mounting, shall be of rigid and substantial design. Doors shall fit closely. The requirements for spacings, barriers and other details of construction, given elsewhere in this section, shall be followed, so far as they apply. Wooden cabinets shall be composed of well-seasoned material at least 3/4 inch in thickness, thoroughly filled and painted. They shall be lined throughout with a non-combustible material, such as 1/8 inch rigid asbestos board firmly secured in place. Linings of slate, marble or approved composition shall be at least 1/4 inch in thickness. Sheet metal lining shall be at least .063 inch in thickness. (No. 16 U. S. sheet metal gauge.)

d. Composition cabinets shall be submitted for approval prior to installation.

e. 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. There shall be an air space of at least 1/16 inch, except at points of support, between the base of the device and the wall of any metal cabinet or cutout box, on which the device is mounted.

2. There shall be an air space of at least 1 inch between any live metal part (including live metal parts of inclosed 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 U. S. sheet metal gauge (0.109 inch), when the air space shall be not less than 1/2 inch.

3. 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. 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 where the potentials do not exceed 250 volts. This spacing shall be increased to at least one inch where the potentials exceed 250 volts.

f. Cabinets and cutout boxes shall be deep enough to allow of the closing of the doors when 30 ampere branch circuit panel-board 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.

g. Cabinets and cutout boxes which contain devices or apparatus connected within the cabinet or box to the wires of more than four circuits, including 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, unless the wires leave the cabinet or cutout box directly opposite their terminal connections.

h. Side wiring spaces, side gutters or side wiring compartments of cabinets shall be rendered tight inclosures 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 inclosure contains only those wires or cables 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 inclosed back wiring spaces shall be provided with covers to complete the inclosure. Wiring spaces that are required by paragraph g of this order and which are exposed when doors are open, shall be provided with covers to complete the inclosure.

i. Cabinets and cutout boxes intended for outdoor use shall be of approved weatherproof type.

Order 1307.03. Construction of Auxiliary Gutters.

a. Gutters shall be so designed 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 inclosure 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 (U. S. Standard Sheet Metal Gage)
Up to and including 4 inches	No. 16—.062 inch
Over 4 inches and not over 18 inches	No. 14—.078 inch
Over 18 inches and not over 30 inches	No. 12—.109 inch
Over 30 inches	No. 10—.140 inch

SECTION 130.8. AUTOMATIC OVERLOAD PROTECTION OF CIRCUITS AND APPLIANCES

Cutout Bases, Fuses, Thermal Cutouts and Circuit-Breakers; Protection of Wires, Circuits, Motors and Appliances.

The requirements of this section do not apply to street car-lighting cutouts nor to protective devices for signal systems.

Order 1308.01. Cutout Bases.

a. Automatic overcurrent protective devices shall be of approved types.

b. Cutout bases for link fuses shall be approved only for use with fuses rated at more than 600 amperes. When used they shall provide the spacings called for in paragraphs a, b and c of Order 1308.01 of the 1930 edition of this code.

c. The fuse terminals of inclosed fuse cutout bases shall be of either the screw-shell plug, spring-clip, knife-blade or other approved standardized type to take corresponding standard inclosed fuses.

d. Cutout bases for inclosed plug or cartridge fuses shall be classified as regards both current and voltage as given in the following table, and shall be so designed that the bases of one class cannot be used with fuses of another class rated for a higher current or voltage.

STANDARD CARTRIDGE FUSE CUTOUT BASES

Not over 250 volts	Not over 600 volts
0– 30 amperes	0– 30 amperes
31– 60 "	31– 60 "
61–100 "	61–100 "
101–200 "	101–200 "
201–400 "	201–400 "
401–600 "	401–600 "

STANDARD PLUG FUSE CUTOUT BASES

Not over 250 volts
0–30 amperes

NON-TAMPERABLE PLUG FUSE CUTOUT BASES

Not over 250 volts
0–15 amperes
16–25 amperes

Order 1308.02. Link Fuses.

a. Link fuses shall not be installed except by permission of the authority enforcing this code. When used in capacities from 601 to 1500 amperes they shall be of dimensions and other characteristics specified in paragraphs a to d inclusive of Order 1308.02 of the 1930 edition of this code.

Order 1308.03. Inclosed Fuses.

a. Inclosed fuses shall be classified to correspond with the several classes of standard cutout bases and shall be so designed that it will be impossible to put any fuse of a given class into a cutout base which is designed for a current or voltage lower than that of the class to which the fuse belongs.

b. Each fuse shall be marked with its ampere capacity. On ferrule contact fuses this marking shall be on the tube or ferrules and on knife-blade fuses, on the tubes or caps. In addition to the above marking each cartridge fuse shall be provided with a paper label, red for 600-volt fuses, navy blue for 250-volt fuses of 15 amperes or less capacity, and green for 250-volt fuses of over 15 amperes capacity. Such labels for cartridge fuses shall bear the following: the name or trademark of the manufacturer and the voltage for which the fuse is designed.

c. Plug fuses of 15 amperes capacity or less shall be distinguished from those of larger capacity as follows: 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.

d. The styles of inclosed plug and cartridge fuse terminals shall be as follows:

Not over 250 volts.

0– 15 Amps. 16– 25 "	Approved plugs for use with standard 0–30 Amp. screw shell plug cutout bases and with cutout bases of the non-tamperable type as specified in Order 1308.04 of this section.
0– 30 Amps.	A. Cartridge fuse (ferrule contact). B. Approved plugs or cartridge fuses in approved casings, for use with screw-shell plug cutout bases.
31– 60 "	Cartridge fuse (ferrule contact).
61–100 " 101–200 " 201–400 " 401–600 "	Cartridge fuse (knife-blade contact).

Not over 600 volts.

0– 30 Amps. 31– 60 "	Cartridge fuse (ferrule contact).
61–100 " 101–200 " 201–400 " 401–600 "	Cartridge fuse (knife-blade contact).

e. Approved plug cutout bases and fuses may be used on voltages not exceeding 125 but including any feeder or circuit of a system having a grounded neutral, if no wire of the feeder or circuit exceeds 150 volts to ground.

f. Cartridge inclosed fuses and corresponding cutout bases shall, according to their current and voltage classifications, conform to the Table of Dimensions of the National Electrical Code Standard Cartridge Inclosed Fuse given on pages 262 and 263 of the 1930 edition of this code.

Order 1308.04. Non-Tamperable Plug Cutout Bases and Fuses.

a. In addition to the provisions of Orders 1308.01 and 1308.03 of this section, and where overcurrent protection is required by other orders of this code, it shall be permissible to use an approved type of non-tamperable plug cutout bases and fuses when constructed according to the following specifications:

1. Plug fuses may be rendered non-tamperable either by the use of an adapter in a standard plug fuse cutout base or by the use of a special cutout base. Non-tamperable plug fuses of the 16–25 ampere classification shall not be usable with the special bases or adapters for non-tamperable fuses of the 0–15 ampere classification.

2. They shall be of such a type and so designed as to be subject to tampering or bridging only with difficulty.

3. When installed and fully assembled they shall have no live parts exposed.

4. The adapter used with this fuse must be so designed that once inserted into the cutout base it cannot be removed.

5. The adapter and the non-tamperable cutout base shall be of such design as to be capable of receiving only a fuse plug constructed to the above specifications.

6. Fuses, bases and adapters of various manufacturers shall be interchangeable with each other.

Order 1308.05. Circuit-breakers. Thermal Cutouts, Thermal Relays, Etc.

a. All circuit-breakers shall have easily accessible means for their manual opening and closing without injury to the operator and shall also indicate whether the circuit-breaker is open or closed.

b. An air circuit-breaker used for 15 ampere and/or appliance branch-circuits, shall be of such a design that any alteration of its trip point (calibration) or in the time required for its operation on over-current will be difficult.

c. Thermal cutouts, thermal relays and other devices for motor running protection (which are not designed to open short circuits and may not, therefore, be classed as circuit-breakers) shall be of approved types and shall be installed in suitable inclosures. They shall be protected by fuses or circuit-breakers having ratings or settings not in excess of four times the motor full load current except as permitted in 1308.08–b–2, exception 1 for group installations.

Order 1308.06. General: Use of Overcurrent Devices (Automatic Overcurrent Protection).

a. In general, overcurrent devices shall be provided in all constant-potential interior wiring systems, and so placed as to protect each ungrounded conductor. The overcurrent device shall be located at the point where the conductor receives its supply except where specifically permitted to be located elsewhere by this or other orders of this code.

b. Nothing in this order shall be considered as prohibiting the use of two single-pole circuit-breakers for the protection of ungrounded 2-wire circuits or the outside wires of 3-wire direct-current and single-phase circuits.

c. In general, a conductor shall be considered as properly protected by the automatic overcurrent protective device employed in series with it when the automatic overcurrent protective device is so selected or adjusted as to open and interrupt the circuit at a current predetermined as follows:

1. When fuses are used they shall be selected so as to have ratings not greater than the allowable carrying capacities of wires, as established in Table 1, Order 1306.12, Section 130.6 of this code.

2. When circuit-breakers are used, they shall be so selected or adjusted as to operate at not greater than 125 per cent of the allowable carrying capacities of wires as established in Table 1, Order 1306.12, Section 130.6 of this code. Under certain limited conditions as provided for under specific uses and as covered in this and subsequent orders of this section, the above general requirements shall be modified. Some of these cases are covered under special headings, such as Motors and Motor-Circuits.

d. Conductors of less current-carrying capacity than the buses, mains, feeders or sub-feeders by which they are supplied shall be considered as properly protected from overcurrent under the following conditions:

1. Where the over-current device protecting the bus, main feeder or sub-feeder also protects the smaller conductor in accordance with Order 1306.12 of Section 130.6.

2. Where the smaller conductor has a current-carrying capacity of not less than the sum of the allowable current-carrying capacities for conductors of the circuits or loads, one or more, which it supplies, provided the tap is not over five feet long and does not extend beyond the switchboard, panelboard or control devices which it supplies and is inclosed in conduit or in a metal gutter when not a part of the

switchboard or panelboard. In every case there shall be suitable over-current protection for the circuits or loads supplied by the unprotected tap.

3. Where the smaller conductors have a current-carrying capacity at least one-third that of the rating of the fuse or setting of the circuit-breaker protecting the bus, main, feeder or sub-feeder 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 terminates in a single circuit-breaker or a single set of fuses which will limit the load on the tap to that allowed by the Tables in Order 1306.12 of Section 130.6.

After passing through the single circuit-breaker or single set of fuses, the conductors may supply any number of circuit-breakers or sets of fuses.

e. No overcurrent device shall be placed in any permanently grounded conductor unless the device simultaneously opens all conductors of the circuit and except as provided in Order 1320.03 of Section 132.0 of this code.

f. At the locations in interior wiring systems where the size or capacity of conductors is changed and overcurrent devices are inserted to properly protect the smaller conductors, the size of a grounded conductor may be changed in proportion to the reduction in size of the ungrounded conductors although no overcurrent device is provided for such grounded conductor.

g. Overcurrent devices shall not be placed where exposed to mechanical injury nor in the vicinity of easily ignitible material. Except when mounted on switchboards or the equivalent which are located in approved rooms or fireproof electric closets, overcurrent devices shall be inclosed in approved cabinets or cutout boxes. They shall, in all cases, be placed in readily accessible locations.

h. Overcurrent devices when installed in locations exposed to moisture shall be mounted in cutout boxes or cabinets approved for the conditions.

i. Cabinets inclosing overcurrent devices shall in all cases be placed in a vertical position except by special permission and under conditions whereby overcurrent devices installed in such cabinets are thoroughly safeguarded from attendant hazards.

j. Except as otherwise provided in this order, in Order 1308.08 of this section and in Section 132.0 the rated capacity of fuses shall not exceed the allowable carrying capacity of the wire as given in Order 1306.12 of this code; and circuit-breakers shall not be set more than 25 per cent above the allowable carrying capacity of the wire unless a fuse of a rating which properly protects the wires is also installed in the circuit.

k. For the protection of wires having safe carrying capacities exceeding the rated capacity of the largest approved inclosed-type fuse, approved inclosed fuses arranged in multiple may be used, provided as few fuses as possible are used and the fuses are of equal capacity and provided the cutout terminals are mounted on a single continuous pair of substantial busbars or have an equivalent arrangement that will eliminate any potential difference between them. The total capacity of the fuses shall not exceed the safe carrying capacity of the wires. This paragraph shall not apply to motor-branch circuits.

l. Fixture wires or flexible cords, sizes No. 16 or No. 18, shall be considered as protected by 15-ampere overcurrent devices. Flexible cords, No. 18 or larger, approved for use with specific appliances which may be used on appliance branch circuits described in Order 1320.06, shall be considered as protected by the 25-ampere overcurrent protection of such circuits.

m. Fused rosettes shall not be used. (See Order 1314.06d)

n. An automatic circuit-breaker, except as provided for generators in Order 1310.02 of this code, when installed without other automatic overcurrent protective devices, shall have one pole in each ungrounded conductor.

o. The number of overcurrent units for the protection of circuits (other than at services) shall not be less than shown in the following table.

(For table of over-current units for motor protection, see Order 1308.08c–4.)

For services, see Order 1304.05.

SYSTEM	*Number and location of Over-current Units, such as Trip coils or Relays.
2-Wire, Single-phase A. C. or D. C. Ungrounded	One (in either conductor. Place always in conductors connected to same side of the circuit. 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.	Where a group of feeders is fed from the three phases of a common three-phase bus, each conductor served by either of two conductors of the three-phase bus must be equipped with one over-current unit. This will result in some circuits being equipped with one unit and others with two units. 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., Neutral Grounded or Ungrounded.	Two (one in each conductor except neutral conductor. Fig. 6.)
3-Wire, 2-Phase, A. C. Common Wire Grounded or Ungrounded	Two (one in each conductor except common conductor. Fig. 7.)
4-Wire, 2-Phase, Ungrounded. Phases Separate.	Two (one in each phase. Place always in conductors connected to same side of the circuit in each phase. Fig. 8.)
4-Wire, 2-Phase, Grounded Neutral, or 5-Wire, 2-Phase, Grounded or Ungrounded.	Four (one in each conductor except neutral conductor. Fig. 9.)
3-Wire, 3-Phase, Ungrounded.	a. Three (one in each conductor if the circuit is served by transformers whose primaries are connected in Y and neutral not connected to system or grounded. Fig. 10.) b. Two, under all other conditions. Place always in same phases.
3-Wire, 3-Phase, 1 Wire Grounded.	Two (one in each ungrounded conductor. Fig. 11.)
3-Wire, 3-Phase, Grounded Neutral.	Three (one in each conductor. Fig. 12.)
4-Wire, 3-Phase, Neutral Grounded or Ungrounded.	Three (one in each conductor except neutral conductor. Fig. 13.)

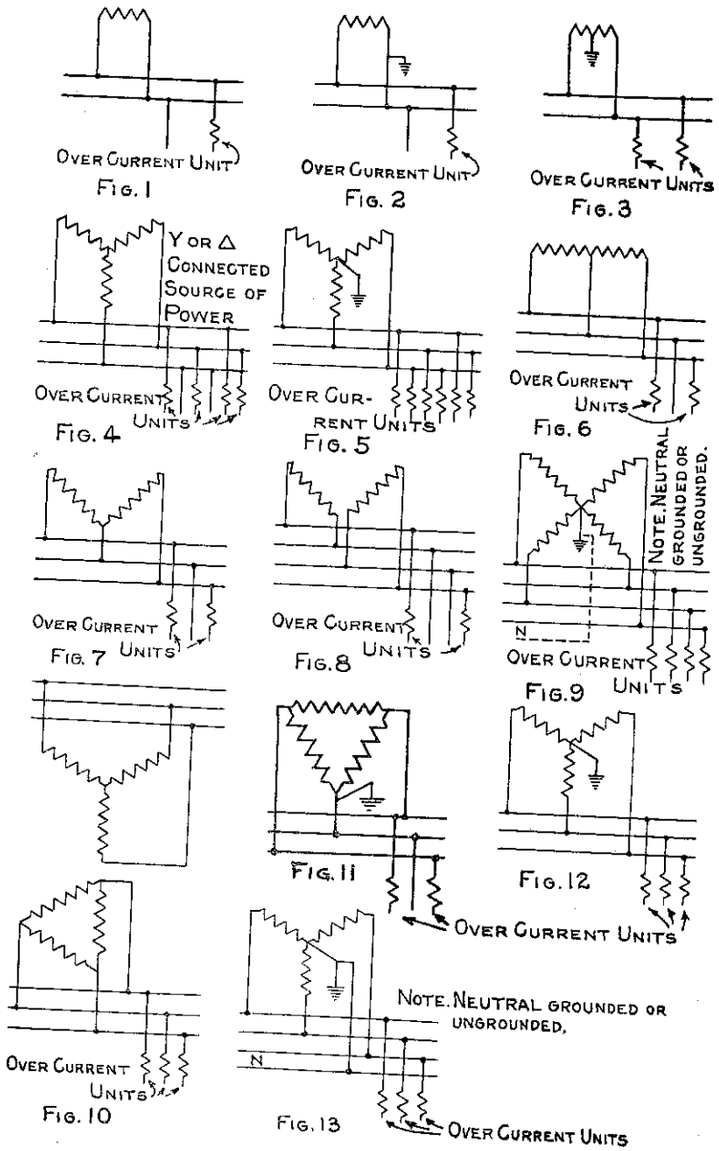
* 1. Where the above table calls for one over-current unit, this may consist of one series over-current tripping device, or the combination of one current transformer and one secondary over-current tripping device.

2. Where it calls for two over-current units, these may consist of two series over-current tripping devices or the combination of two current transformers and two secondary over-current tripping devices.

3. Where it calls for three over-current units, these may consist of three series over-current tripping devices or the combination of two or three secondary over-current tripping devices with three current transformers.

4. Where it calls for four over-current units, these may consist of four series over-current tripping devices or four current transformers with four secondary over-current tripping devices.

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



p. Disconnection of Fuses and Thermal Cutouts Before Handling.

Automatic disconnection—Fuses in circuits of more than 150 volts to ground shall, where accessible to others than qualified electrical attendants, be so arranged that the fuses are necessarily disconnected from all sources of electrical energy before they can be touched. Where the circuit voltage is less than 150 volts to ground, this protection is recommended.

Exception: Where fuses are in locked cabinets (or otherwise made accessible only to qualified persons) sufficient protection is usually secured for all voltages if switches are provided to disconnect the fuses from all sources of electrical energy.

Note: (1) This may be accomplished by a construction in which the fuse and its exposed current carrying connections are accessible only when disconnected from the circuit, either by opening the fuse inclosure or by other means.

(2) When switches and fuses are inclosed in metal cabinets and live terminals are accessible, greater hazard exists than if they were not so inclosed, as the live terminals are adjacent to grounded metal.

q. *Arcing or Suddenly Moving Parts.*

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

2. Handles or levers of circuit breakers or 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.

r. *Inclosure.* Current-carrying parts of switches, fuses, or automatic circuit breakers of more than 300 volts to ground shall be provided with inclosure guards, effective during ordinary operation; and if accessible to other than qualified persons, current-carrying parts of more than 100 volts to ground shall be provided with such inclosing guards.

s. *Platforms and mats.* Where switches or fuses of more than 150 volts to ground are not guarded during ordinary operation, suitable insulating floors, mats or platforms shall be provided on which the operator must stand while handling the switches, fuses, or automatic circuit breakers and (unless operators invariably wear suitable insulating gloves while handling the switches) any conducting walls or machine frames within 3.5 feet shall be provided with suitable insulating guards.

Note: The suitable guarding of live parts will obviate the necessity of such insulating floors and other devices, and where use of such devices is impracticable from the nature of the location or mechanical process carried on, guards should always be used.

Order 1308.07. Services.

For equipment at services including automatic overcurrent protective devices, see Order 1304.05 and Order 1350.09 of this Code.

Order 1308.08. Motors and Motor Circuits.

MOTORS USED FOR CONTINUOUS DUTY

See Figure 14.

a. Motor Feeder Conductors. (Size and Protection.)

1. Feeder conductors supplying a group of two or more motors shall have a current-carrying capacity not less than 125 per cent of the full-load current rating of the largest motor in the group plus the sum of the full-load current ratings of the remainder of the motors in the group. The rating of a fuse or setting of a circuit-breaker installed as automatic overcurrent protection for the feeder conductors shall not be greater than the largest rating or setting of branch-circuit protective device for any motor in the group (based on Table 6 of this order) plus the sum of the full-load currents of the other motors in the group.

Where a number of 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. For long runs it may be necessary in order to avoid excessive voltage drop, to use conductors of larger capacity than the minimum capacity required by the above paragraph.

Where two or more motors of a group must be started simultaneously it may be necessary to install larger feeder conductors and correspondingly larger ratings or settings of feeder overcurrent protection.

EXAMPLE. Determine the size and protection of feeder conductors supplying one 25 H.P. squirrel cage induction motor (full-voltage starting) and two 30 H.P. slip-ring induction motors on a 440-volt 3-phase 60-cycle supply.

CONDUCTOR SIZE. The full load current of the 25 H.P. motor is 32 amperes and of the 30 H.P. motor 39 amperes (from Table 5) the feeder conductor capacity is, therefore, 125% of 39, plus 39, plus 32 or 120 amperes. A No. 0 feeder conductor is therefore the minimum allowable size when rubber insulation is used.

FEEDER PROTECTIVE DEVICE. The rating of branch-circuit fuse for a 25 H.P. squirrel cage motor is 300% of 32 amperes or 96 amperes, and for a 30 H.P. slip-ring motor is 150% of 39 amperes or 59 amperes. The rating of a feeder fuse is, therefore, 96 + 39 + 39 or 176 amperes, and a 200 ampere fuse is the maximum size which may be used.

The setting of a branch-circuit circuit-breaker for a 25 H.P. squirrel cage motor is 250% of 32 amperes, or 80 amperes, and for a

30 H.P. slip-ring motor is 150% of 39 amperes or 59 amperes. The maximum setting of a feeder circuit-breaker is 80 + 39 + 39 or 158 amperes.

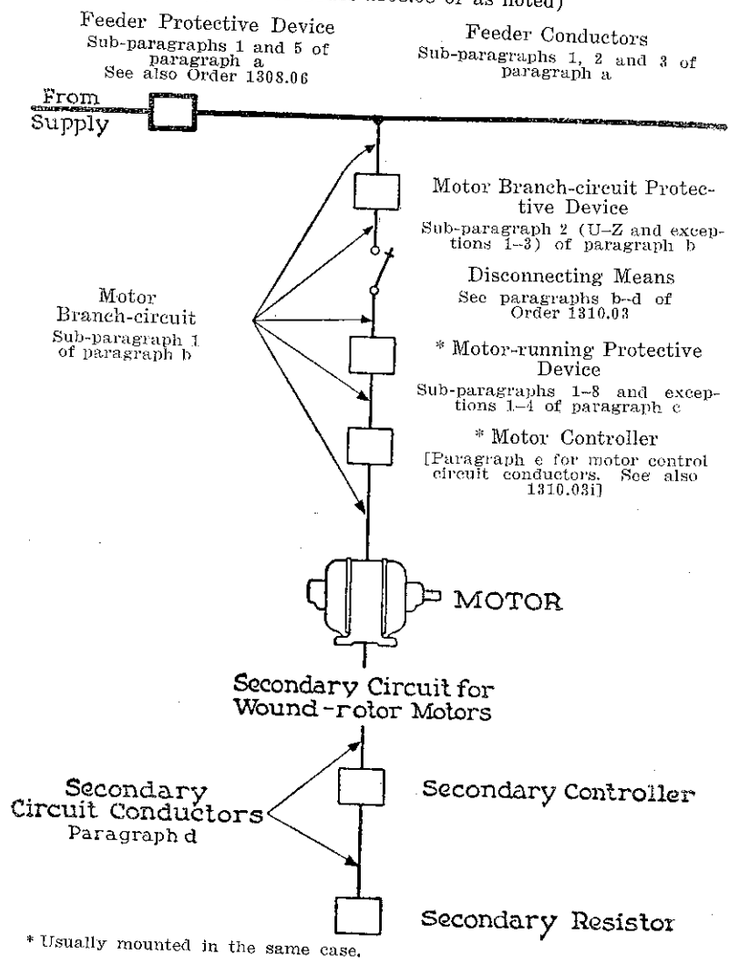
2. In many cases the carrying capacity of the conductors of a feeder or main circuit supplying a group of motors need not be as great as determined by the foregoing on account of reduced heating of the conductor resulting from the motors operating on a duty-cycle or from all motors not operating at any one time. The authority enforcing this code may permit the use of a demand factor in determining the conductor size, the value of the factor depending upon the sizes and numbers of motors supplied and the characters of their loads and duties.

3. Feeder conductors supplying a combined lighting or lighting and appliance load and a motor load shall have a minimum current-carrying capacity equivalent to the required capacity for the lighting and/or appliance load plus the required capacity for the motor load determined in accordance with the preceding provisions of this paragraph or those for single motor loads in following paragraphs. The rating of the fuse or setting of a circuit-breaker installed for automatic overcurrent protection for the feeder conductors shall not be greater than the rating or setting determined for the motor load, in accordance with this section, plus the appropriate rating or setting for the lighting and/or appliance load.

FIGURE 14

MOTOR FEEDER AND BRANCH-CIRCUITS

(Refer to Order 1308.08 or as noted)



* Usually mounted in the same case.

b. Motor-Branch-Circuit Conductors (Size and Protection).

1. Conductors supplying an individual motor shall have a minimum carrying capacity of 125 per cent of the motor full-load current. The sizes of the conductors calculated

on this basis for the more usual ratings are given in columns 2, 3 and 4 of Table 1 of this order.

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 1.

2. Except as provided in Exceptions 1, 2 and 3 hereto, a motor branch-circuit protective device consisting of a time-limit circuit-breaker, an instantaneous type circuit-breaker, or of a fuse, shall be provided in each ungrounded conductor of a motor branch-circuit. Branch-circuit protective devices shall provide short-circuit protection for the motor-branch-circuit conductors, motor-running protective device and the motor.

u. The maximum rating or setting of motor branch-circuit protective devices shall be in accordance with the percentage of full-load current given in Table 6 of this order. The fuse ratings calculated on this basis for the more usual sizes may be read from Table 1, columns 7, 8 and 9.

v. When fuses are used as motor branch-circuit protective devices, they shall be placed in all ungrounded conductors.

w. When circuit-breakers are used as motor-branch-circuit protective devices, they shall be operative to open all ungrounded conductors and shall be equipped with overcurrent units in accordance with paragraph o of Order 1308.06.

x. Circuit-breakers for motor-branch-circuit protection shall have continuous current ratings not less than 115 per cent of the full-load current ratings of the motors.

y. Although it is desirable to keep the motor branch-circuit protection at as low a rating as is possible, cutout bases for such motor branch-circuit fuses shall not be of a smaller size than that required to accommodate the motor branch-circuit fuses specified in the tables for any value of motor full-load current.

z. The rating of a combination cutout and switch at a service supplying motors or at a tap for a motor branch-circuit, shall be such that the cutouts will accommodate fuses rated not less than is specified in the tables for motor branch-circuit fuses.

Exceptions. The following exceptions to the foregoing provisions of this paragraph b–2, shall be recognized:

1. When in a group of motors each is protected by a motor-running protective device which has been approved for group installation, the motor branch-circuit protective device may be omitted provided the feeder conductors supplying the group are protected by fuses having a rating not exceeding that indicated on the smallest motor-running protective device of the group, and also provided the motor branch-circuit conductors to the motor-running protective device have either (a) the same current-carrying capacity as the feeder or (b) at least ⅓ the current-carrying capacity of the feeder with a minimum in accordance with paragraph b–1 of this order, the conductors to the motor-running protective device in the latter case being not more than 25 feet long and being suitably protected from mechanical injury. (Where feeders are at a greater elevation, this distance may be increased to 50 feet.)

Short circuit tests are made in order to determine the maximum rating of fuse which may be used in series with a given motor running protective device without introducing a fire hazard. Overcurrent units in the motor running protective device may, however, be destroyed on the occurrence of a short circuit, thus requiring replacement of the overcurrent units.

2. The motor branch-circuit protective device may be placed where it will be accessible when the location of the tap to the feeder conductors is not accessible provided the size and the installation of the conductors of the motor branch-circuit from the feeder to the motor-branch-circuit protective device are in accordance with (a) or (b) of the foregoing Exception 1.

3. When it is found that the maximum rating or setting of the motor-branch circuit protective device allowed in the tables is not large enough to allow the motor to start, the authority enforcing this Code may permit a sufficient increase in the rating or setting of the protective devices to permit the motor to start, but in no case shall it exceed a maximum of 400 per cent of the motor full-load current.

c. Motor-Running Protection. Motor-running protective devices consisting of circuit-breakers, controllers with overcurrent units, thermal cutouts, fuses or other devices approved for the purpose shall be required for each motor to protect the motor and motor branch-circuit conductors against normal operating overloads.

1. The maximum rating of fuses and thermal cutouts, and the maximum setting of over-current units of circuit-breakers or controllers, when used as motor-running protective devices shall be 125 per cent of the motor full-load current. The rating or setting calculated on this basis for the more usual sizes is given in columns 5 and 6 of Table 1

of this order. Where the values given in column 6 do not correspond to the standard sizes or ratings of thermal cutouts and thermal relays, the next higher standard size or rating may be used.

2. Motor-running protective devices other than fuses shall have a continuous current-carrying capacity of at least 115 per cent of the full-load current rating of the motor.

3. When fuses are used as motor-running protective devices, they shall be inserted in all ungrounded conductors. In general, it is necessary to shunt fuses out during the starting period. See exception 3 following.

4. When automatic overcurrent protective devices other than fuses are used for motor-running protection, the following table shall govern the minimum allowable number and the location of the 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 cutouts.
1-phase A. C. or D. C.	2-wire, 1 phase A. C. or D. C., ungrounded	1 in either conductor.
1-phase A. C. or D. C.	2-wire, 1-phase A. C. or D. C., one conductor grounded	1 in ungrounded conductor.
1-phase A. C. or D. C.	3-wire, 1-phase A. C. or D. C., grounded-neutral	1 in 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.

5. When automatic overcurrent-protective devices other than fuses and thermal cutouts are used as motor-running protective devices, they shall be operative to open automatically on overcurrent at least sufficient ungrounded conductors to interrupt all current flow to the motor.

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

6. The controller for a D. C. motor may also serve as the motor-running protective device provided it is equipped with the number of overcurrent units (trip coils, relays, or thermal cutouts) called for in the table of sub-paragraph (4) of this order, and these overcurrent units are operative in both the starting and running positions.

7. The controller for an A. C. motor may also serve as the motor-running protective device provided it is equipped with the number of overcurrent units (trip coils, relays or thermal cutouts) called for in the table of sub-paragraph (4) of this order and these units are operative in the running position.

8. The rating of a combination cutout and switch used as a motor-controller shall be such that the cutout will accommodate the size of fuse specified in the table for motor-running protection.

Exceptions: The following exceptions to the foregoing provisions of this paragraph (c) shall be recognized:

1. Motors of 1 H.P. or less shall be considered as being sufficiently protected by the automatic over-current protective devices used to protect the motor branch-circuit conductors as specified in the following tables.

It is recommended that the motor-running protection specified in the following tables be provided for all such small motors when they are located out of sight of the operator.

2. Two or more small motors grouped under the protection of a single set of overcurrent devices and with or without other current-consuming devices in the circuit shall be considered as being sufficiently protected if the rating or setting of the overcurrent device does not exceed 15 amperes at 125 volts nor 10 amperes at 250 volts and the total load of the circuit does not exceed 1320 volt-amperes, or by the 25 ampere overcurrent devices of the appliance circuit described in Order 1320.06 of Section 132.0. No individual motor of such a group shall have a full-load rated current of more than six amperes.

3. Motor-running protective devices may be shunted or cutout during the starting period by a switch which cannot be left in the starting position and the motor and motor-branch circuit shall be considered sufficiently protected during this starting period, provided that next back on the line there are fuses rated, or a time-limit circuit-breaker set, at not more than 400 per cent, or an instantaneous type circuit-breaker set at not more than 700 per cent, of the motor nameplate current rating.

4. For the protection of motors used on cranes or hoists, see Order 1330.06 of Section 133.0 of this code.

TABLE 1

For Selecting Wire and Fuse Sizes for Motor Branch-Circuits

Full-load current rating of motor	Minimum allowable size of copper wire Am. gauge or cir. mils.			For Running Protection of Motors		Maximum Allowable Rating of Branch Circuit Fuses (See table 6 of this order.)		
	Rubber	Varnished Cambric	Slow-Burning	Max. Rating of N. E. C. fuses	Max. Setting of time-limit protective device	Squirrel-cage and synchronous (full-voltage reactor and resistor starting.) Single-phase	Squirrel-cage and synchronous (auto-transformer starting.) High-reactance squirrel-cage***	Wound Rotor A. C. and D. C.
Amperes				Amperes	Amperes	Amperes	Amperes	Amperes
Col. No. 1	2	3	4	5	6	7	8	9
1**	14	14	14	2*	1.25*	15	15	15
2**	14	14	14	3*	2.50*	15	15	15
3**	14	14	14	4*	3.75*	15	15	15
4**	14	14	14	6*	5.0 *	15	15	15
5**	14	14	14	8*	6.25*	15	15	15
6**	14	14	14	8*	7.50*	20	15	15
7	14	14	14	10*	8.75*	25	20	15
8	14	14	14	10*	10.0 *	25	20	15
9	14	14	14	12*	11.25*	30	25	15
10	14	14	14	15*	12.50*	30	25	15
11	14	14	14	15*	13.75*	35	30	20
12	14	14	14	15	15.00	40	30	20
13	12	14	14	20	16.25	40	35	20
14	12	14	14	20	17.50	45	35	25
15	12	12	14	20	18.75	45	40	25
16	12	12	14	20	20.00	50	40	25
17	10	12	12	25	21.25	60	45	30
18	10	12	12	25	22.50	60	45	30
19	10	12	12	25	23.75	60	50	30
20	10	12	12	25	25.0	60	50	30
22	8	10	10	30	27.50	70	60	35
24	8	10	10	30	30.00	80	60	40
26	8	8	8	35	32.50	80	70	40
28	8	8	8	35	35.00	90	70	45
30	6	8	8	40	37.50	90	70	45
32	6	8	8	40	40.00	100	70	50
34	6	6	8	45	42.50	110	70	60
36	6	6	8	45	45.00	110	80	60
38	6	6	8	50	47.50	125	80	60
40	6	6	8	50	50.00	125	80	60
42	5	6	6	50	52.50	125	90	70
44	5	6	6	60	55.0	125	90	70
46	4	6	6	60	57.50	150	100	70
48	4	6	6	60	60.0	150	100	80
50	4	5	6	60	62.50	150	100	80
52	4	5	6	70	65.0	175	110	80
54	4	4	6	70	67.50	175	110	90
56	4	4	6	70	70.00	175	120	90
58	3	4	5	70	72.50	175	120	90
60	3	4	5	80	75.00	200	120	90
62	3	4	5	80	77.50	200	125	100
64	3	4	5	80	80.00	200	150	100
66	2	4	4	80	82.50	200	150	100
68	2	4	4	90	85.00	225	150	110
70	2	3	4	90	87.50	225	150	110
72	2	3	4	90	90.00	225	150	110
74	1	3	3	90	92.50	225	150	125
76	1	3	3	100	95.00	250	175	125
78	1	2	3	100	97.50	250	175	125
80	1	2	3	100	100.00	250	175	125
82	0	2	2	110	102.50	250	175	125
84	0	2	2	110	105.00	250	175	150
86	0	2	2	110	107.50	300	175	150
88	0	2	2	110	110.00	300	200	150
90	0	1	2	110	112.50	300	200	150
92	0	1	2	125	115.00	300	200	150
94	0	1	2	125	117.50	300	200	150
96	0	1	2	125	120.00	300	200	150
98	0	0	2	125	122.50	300	200	150

TABLE 1—Continued

For Selecting Wire and Fuse Sizes for Motor Branch-Circuits—Continued

Full-load current rating of motor	Minimum allowable size of copper wire Am. gauge or cir. mils.			For Running Protection of of Motors		Maximum Allowable Rating of Branch Circuit Fuses (See table 6 of this order.)		
	Rubber	Varnished Cambric	Slow-Burning	Max. Rating of N. E. C. fuses	Max. Setting of time-limit protective device	Squirrel-cage, and synchronous (full-voltage, reactor and resistor starting.) Single-phase	Squirrel-cage, and synchronous (auto-transformer starting.) High-reactance squirrel-cage***	Wound Rotor A C. and D. C
Amperes				Amperes	Amperes	Amperes	Amperes	Amperes
Col. No. 1	2	3	4	5	6	7	8	9
100	0	0	2	125	125.00	300	200	150
105	00	0	1	150	131.5	350	225	175
110	00	0	1	150	137.5	350	225	175
115	00	0	1	150	144.0	350	250	175
120	00	0	1	150	150.0	400	250	200
125	000	00	0	175	156.5	400	250	200
130	000	00	0	175	162.5	400	300	200
135	000	00	0	175	169.0	450	300	225
140	000	00	0	175	175.0	450	300	225
145	200,000	000	0	200	181.5	450	300	225
150	200,000	000	0	200	187.5	450	300	225
155	200,000	000	0	200	194.0	500	350	250
160	200,000	000	0	200	200.0	500	350	250
165	0000	000	00	225	206.	500	350	250
170	0000	200,000	00	225	213.	500	350	300
175	0000	200,000	00	225	219.	600	350	300
180	0000	200,000	00	225	225.	600	400	300
185	250,000	200,000	000	250	231.	600	400	300
190	250,000	200,000	000	250	238.	600	400	300
195	250,000	0000	000	250	244.	600	400	300
200	250,000	0000	000	250	250.	600	400	300
210	300,000	0000	000	250	263.	----------	450	350
220	300,000	250,000	000	300	275.	----------	450	350
230	350,000	250,000	200,000	300	288.	----------	500	350
240	350,000	250,000	200,000	300	300.	----------	500	400
250	400,000	300,000	0000	300	313.	----------	500	400
260	400,000	300,000	0000	350	325.	----------	600	400
270	500,000	350,000	250,000	350	338.	----------	600	450
280	500,000	350,000	250,000	350	350.	----------	600	450
290	500,000	350,000	300,000	350	363.	----------	600	450
300	500,000	400,000	300,000	400	375.	----------	600	450
320	500,000	500,000	300,000	400	400.	----------	----------	500
340	600,000	500,000	350,000	450	425.	----------	----------	600
360	600,000	500,000	350,000	450	450.	----------	----------	600
380	700,000	500,000	400,000	500	475.	----------	----------	600
400	700,000	600,000	400,000	500	500.	----------	----------	600
420	800,000	600,000	500,000	600	525.	----------	----------	----------
440	800,000	700,000	500,000	600	550.	----------	----------	----------
460	900,000	700,000	500,000	600	575.	----------	----------	----------
480	900,000	700,000	500,000	600	600.	----------	----------	----------
500	1,000,000	800,000	600,000	----------	625.	----------	----------	----------
520	1,000,000	800,000	600,000	----------	650.	----------	----------	----------
540	1,100,000	900,000	600,000	----------	675.	----------	----------	----------
560	1,200,000	900,000	700,000	----------	700.	----------	----------	----------
580	1,200,000	1,000,000	700,000	----------	725.	----------	----------	----------
600	1,300,000	1,000,000	700,000	----------	750.	----------	----------	----------
625	1,400,000	1,000,000	800,000	----------	782.	----------	----------	----------

*, **, *** See end of table 5 of this section.

d. Secondary-Circuit Conductors. The secondary conductors of a wound-rotor A. C. motor between the slip rings and the controller shall have a carrying capacity which is not less than 125 per cent of the full-load secondary current of the motor and between the controller and resistor a carrying capacity which is not less than that given in the following table:

Resistor Duty Classification (NEMA Apparatus Division)	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

e. Motor Remote-Control-Circuit Conductors.

x. The conductors of the control circuits of remote-controlled apparatus and devices shall be considered as being properly protected by the motor-branch-circuit protective devices under any one of the following conditions:

1. Where the motor-branch-circuit protection is not more than 500 per cent of the carrying capacity of the control-circuit conductors. For switchboards, see 1313.02–h.

2. When the motor-control device and the point of control (start and stop buttons, pressure switch, thermostatic switch, etc.), are both located on the same machine and the control circuit does not extend beyond the machine.

3. In all cases where the opening of the control circuit would create a hazard; as, for example, the control circuit of fire-pump motors, etc.

y. All conductors of such control circuits which are not protected against overcurrent as required in Order 1308.06 or according to the conditions of the preceding paragraph shall be installed in conduit or be otherwise suitably protected from mechanical injury where they extend beyond the control device itself. See also 1310.04–h.

FULL-LOAD MOTOR CURRENTS‡

TABLE 2

Direct-Current Motors

Amperes

H. P.	115 V.	230 V.	550 V.
½*	4.5	2.3	
¾*	6.5	3.3	
1*	8.4	4.2	1.4
1½*	12.5	6.3	1.7
2*	16.1	8.3	2.6
3	23.0	12.3	3.4
5	40	19.8	5.0
7½	58	28.7	8.2
10	75	38	12.0
15	112	56	16.0
20	140	74	23.0
25	185	92	30
30	220	110	38
40	294	146	45
50	364	180	61
60	436	215	75
75	540	268	90
100		357	111
125		443	146
150			184
200			220
			295

TABLE 3

Single-Phase A. C. Motors

Amperes

H. P.	110 V.	220 V.	440 V.
⅙*	3.34	1.67	
¼*	4.8	2.4	
½*	7	3.5	
¾*	9.4	4.7	
1*	11	5.5	
1½	15.2	7.6	
2	20	10	
3	28	14	
5	46	23	
7½	68	34	17
10	86	43	21.5

For full-load currents of 208 and 200-volt motors, increase corresponding 220-volt motor full-load current by 6 and 10 per cent, respectively.

‡ See end of Table 5 of this section.

TABLE 4

Two-Phase A. C. Motors (4-wire)†

H.P.	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type ****Unity Power Factor Amperes			
	110V	220V	440V	550V	2200V	220V	440V	550V	2200V
½*	4.3	2.2	1.1	.9	—	—	—	—	—
¾*	4.7	2.4	1.2	1.0	—	—	—	—	—
1 *	5.7	2.9	1.4	1.2	—	—	—	—	—
1½	7.7	4.0	2	1.6	—	—	—	—	—
2	10.4	5	3	2.0	—	—	—	—	—
3	—	8	4	3.0	—	—	—	—	—
5	—	13	7	6	—	—	—	—	—
7½	—	19	9	7	—	—	—	—	—
10	—	24	12	10	—	—	—	—	—
15	—	33	16	13	—	—	—	—	—
20	—	45	23	19	—	—	—	—	—
25	—	55	28	22	6	47	24	19	4.7
30	—	67	34	27	7	56	29	23	5.7
40	—	88	44	35	9	75	37	31	7.5
50	—	108	54	43	11	94	47	38	9.4
60	—	129	65	52	13	111	56	44	11.3
75	—	156	78	62	16	140	70	57	14
100	—	212	106	85	22	182	93	74	18
125	—	268	134	108	27	228	114	93	23
150	—	311	155	124	31	—	137	110	28
200	—	415	208	166	43	—	182	145	37

*, **** † See end of Table 5 of this section.

TABLE 5

Three-Phase A. C. Motors

H.P.	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type ****Unity Power Factor Amperes			
	110V	220V	440V	550V	2200V	220V	440V	550V	2200V
½*	5	2.5	1.3	1	—	—	—	—	—
¾*	5.4	2.8	1.4	1.1	—	—	—	—	—
1 *	6.6	3.3	1.7	1.3	—	—	—	—	—
1½	9.4	4.7	2.4	2.0	—	—	—	—	—
2	12	6	3	2.4	—	—	—	—	—
3	—	9	4.5	4	—	—	—	—	—
5	—	15	7.5	6	—	—	—	—	—
7½	—	22	11	9	—	—	—	—	—
10	—	27	14	11	—	—	—	—	—
15	—	38	19	15	—	—	—	—	—
20	—	52	26	21	—	—	—	—	—
25	—	64	32	26	7	54	27	22	5.4
30	—	77	39	31	8	65	33	26	6.5
40	—	101	51	40	10	86	43	35	8.6
50	—	125	63	50	13	108	54	44	10.8
60	—	149	75	60	15	128	64	51	13
75	—	180	90	72	19	161	81	65	16
100	—	240	123	98	25	211	106	85	21
125	—	310	155	124	32	264	132	106	26
150	—	360	180	144	36	—	158	127	32
200	—	480	240	195	49	—	210	168	42

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.

Footnotes to Tables 1–5.

† Values of current in common wire of 2-phase 3 wire system will be 1.41 times value given.

‡ These values of full-load currents are average for all speeds and frequencies.

* For running protection of motors of 1 h.p. and less, see exception 1 of paragraph c of Order 1308.08.

** For the grouping of small motors under the protection of a single set of fuses, see exception 2 of paragraph c of Order 1308.08.

*** 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 90 and 80 per cent P.F. the above figures should be multiplied by 1.1 and 1.25, respectively.

TABLE 6

Maximum Rating or Setting of Motor Branch-Circuit Protective Devices

Type of Motor	Per Cent of Full Load Current: Fuse Rating (See also Table 1, Columns 7, 8, & 9)	Circuit Breaker Setting: Instantaneous Type	Circuit Breaker Setting: Time Limit Type
Single-phase (all types)	300	---	250
Squirrel-cage and synchronous (full-voltage, resistor and reactor starting)	300	---	250
Squirrel-cage and synchronous (auto-transformer starting)			
Not more than 30 amperes	250	---	200
More than 30 amperes	200	---	200
High-reactance squirrel-cage			
Not more than 30 amperes	250	---	250
More than 30 amperes	200	---	200
Slip-ring	150	---	150
Direct-current			
Not more than 50 H.P.	150	250	150
More than 50 H.P.	150	175	150

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.

MOTORS USED FOR OTHER THAN CONTINUOUS DUTY

f. When motors are used on other than continuous duty (short-time, intermittent, periodic or varying duty as defined in the A. I. E. E. Standard), conductors having carrying capacities differing from those given in paragraph b of this order shall be required in the motor branch-circuit. In the majority of cases the carrying capacity need not exceed the percentages of the motor nameplate-current ratings given in the following table. Motors of this class are considered as being sufficiently protected by the branch-circuit protective devices.

Classification of Service	Percentages of Name-Plate Current Rating: 5-Minute Rating	15-Minute Rating	30 & 60 Minute Rating	Continuous Rating
Short-Time Duty				
Operating valves, raising or lowering rolls	110	120	150	---
Intermittent Duty				
Freight and passenger elevators, shop cranes, tool heads, pumps, etc.	85	85	90	140
Periodic Duty				
Hoists, rolls, ore and coal-handling machines	85	90	95	140
Varying duty	110	120	150	200

or lower at the discretion of the authorities enforcing the regulations.

Order 1308.09. Protection of Generators.

See Order 1310.02 of Section 131.0 of this Code.

Order 1308.10. Protection of Electrically Heated Appliances.

See Sections 131.6 and 132.0 of this Code.

Order 1308.11. Protection of Theater Footlights and Border Lights.

a. Theater footlights and border lights shall be so wired that the number of outlets and the lamps connected to them shall in no case be such as to place more than 15 amperes on a branch circuit overcurrent device.

Order 1308.12. Protection of Signs and Outline Lighting.

a. Circuits shall be so arranged that the number of outlets and the lamps connected to them shall in no case be such as to place more than 15 amperes on the branch-circuit overcurrent device.

Order 1308.13. Protection of Switchboard Instruments.

a. Inclosed fuses shall be used to protect instruments and pilot lights on switchboards. Approved inclosed fuses are preferred, but other types may be used provided the rating of such fuses does not exceed two amperes.

Order 1308.14. Protection of Feeders at Supply Stations.

(See also Part I of this code for additional requirements.)

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

Order 1308.15. Protection of Class 3 Signal Systems.

a. Circuits shall be so arranged that they shall in no case place more than 15 amperes on a branch-circuit overcurrent protective device.

SECTION 130.9. GROUNDING

The material formerly in this section has been placed in Section 103 of the Introductory Part.

SECTION 131.0. ROTATING MACHINERY AND ITS CONTROL APPARATUS

For special provisions for hazardous locations see Section 133.2.

Order 1310.01. General.

a. Each generator or motor shall be provided with a name-plate. For generators the name-plate shall give 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. For motors the name-plate shall give the maker's name, the rating in volts and amperes, including those for the secondary of a wound-rotor type motor, the normal full load speed and the interval during which it can operate starting cold, before reaching its rated temperature. The time interval given shall be either 5, 15, 30, or 60 minutes or continuous.

b. Machines shall be provided with suitable drip pans if required by the authority enforcing this code.

c. Live parts of rotating equipment of more than 150 volts to ground, except slip rings and brush rigging which do not extend beyond the frames of induction motors, shall not be exposed to accidental contact where accessible to unqualified persons. For the purpose of this rule, ungrounded circuits fed from transformers or overhead supply circuits are considered as being more than 150 volts to ground.

d. If terminal blocks are used they shall be composed of approved insulating material, such as slate, marble or porcelain.

e. Soft rubber bushings may be used to protect lead wires where they pass through the frame, but only where they will not be exposed to oils, grease, oily vapors or other substances having a deleterious effect on rubber.

Order 1310.02. Generators (Other than in Central Stations).

a. Generators shall be located in dry places. They shall not be placed in a room where any hazardous process is carried on, nor where they will be exposed to flammable gases or flyings of combustible materials.

It is recommended that waterproof covers be provided for use in an emergency.

b. Constant-potential generators, except alternating current machines and their exciters, shall be protected from excessive currents by automatic circuit-breakers or fuses.

Single-pole protection shall be accepted for 2-wire direct-current generators if the protective device is actuated by the entire current generated, except that in the shunt field. The protective device shall not open the shunt field. Generators having a potential of 65 volts or less and driven by individual motors are to be considered as satisfactorily protected by the automatic overcurrent protective devices protecting the motors if these protective devices will operate when the generators are delivering not more than 150 per cent of their full-load rated current.

c. Two-wire, direct-current generators, used in conjunction with balancer sets to obtain neutrals for 3-wire systems, shall be equipped with protective devices which will disconnect the 3-wire systems in the case of excessive unbalancing of voltages.

d. Three-wire, direct-current generators, whether compound or shunt wound, shall be equipped with protective devices, one in each armature lead and so connected as to be actuated by the entire current from the armature. Such protective device shall consist either of a double-pole, double-coil, overcurrent circuit-breaker, or of a 4-pole circuit-breaker connected in the main and equalizer leads and tripped by two overload 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 1310.03. Motors.

For automatic overcurrent protection of motors see Section 130.8.
For installation of motors in hazardous places, see Section 133.2.
For installation of resistors, reactors and capacitors, see Section 131.7.

It is recommended that where conditions are such that 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 the motors be of the totally-inclosed, inclosed fan-cooled, or inclosed pipe-ventilated types, or be inclosed in separate dust-tight rooms or housings so constructed as to adequately exclude dust and be properly ventilated from a source of clean air.

a. Where the wiring to motors, other than portable, is in conduit, armored cable, metal raceways or similar construction, terminal inclosures or housings of substantial metal construction shall be provided at the motor terminals. For a fractional horsepower motor of one-third horsepower or smaller, this terminal inclosure may be separated from the motor not over six feet and the connection between motor

and inclosure may be made with wires smaller than No. 14 but not smaller than No. 18, provided they have carrying capacity of at least 125 per cent of the full-load current rating of the motor and are of armored cable or armored cord or are inclosed in flexible or rigid conduit or in electrical metallic tubing not smaller than ⅜ inch electrical trade size. The conduit, armored cable, or armored cord, or metal raceways shall be mechanically and electrically connected to the terminal inclosures or housings. The terminal inclosures or housings shall be of ample size to properly make connections.

Order 1310.04. Motor Controllers.

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

a. Each motor shall be provided with a controller capable of starting and stopping the motor. By special permission of the authority enforcing this code a single controller may serve a group of motors in cases where other provisions of this code permit a single disconnecting means for such a group.

See Order 1308.06–c for motor protection.

b. Except as provided in paragraph a of Order 1310.05 the controller need not open all conductors to the motor which it controls, provided the disconnecting means specified in Order 1310.05 opens all the ungrounded conductors of the circuit.

It is recommended that the controller open all ungrounded conductors of the circuit.

c. 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.

d. A controller for an alternating current motor shall be capable of interrupting the stalled-rotor current of the motor.

e. Except as provided in sub-divisions 1–4 below, controllers shall have horsepower ratings that shall not be lower than the horsepower ratings of their motors.

1. A branch-circuit type circuit-breaker, rated in amperes only, may be used as a controller if its ampere rating is at least 115 per cent of the full-load current rating of the motor.

2. A general-use switch may be used as a controller for a motor not over 2 horsepower, and not over 300 volts if its ampere rating is at least 200 per cent of the full-load current rating of the motor.

3. An approved attachment plug and receptacle may be used as the controller for a portable motor not larger than ¼ horsepower.

4. For motors, other than portable, not larger than ⅛ horsepower, that are normally left running and are so constructed that they cannot be damaged by overload or failure to start, such as clock motors and the like, the branch-circuit overcurrent protective device may serve as the controller.

f. A motor and its driven machinery shall be within sight of the point where the motor is controlled, except as provided below:

1. Where the controller or its disconnecting means is capable of being locked in the open position.

2. Where a suitable manually operated switch, which will prevent the starting of the motor, is placed within sight of the motor location. The switch may be of the remote control type.

3. Where special permission is given by the authority enforcing this code.

4. As otherwise required in Section 133.2 of this code.

g. 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 design of the motor is such as to permit starting under weakened field.

h. 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 where they extend beyond the control device itself.

Control circuits shall be so arranged that they will be disconnected from all source of supply when the switch which disconnects the control device is in the open position except when a separate switch is used for the control circuit.

Where a transformer or other device is used to obtain a reduced voltage for control circuits, such transformer or other device must be connected to the load side of the disconnecting means.

For the overcurrent protection of remote control circuits see 1308.08–e.

i. A double-throw switch used to shunt the motor protective device during the starting period shall be of such type that it cannot be left in the starting position.

j. 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.

k. Auto-transformer starters shall have all live parts suitably enclosed.

l. Where the restarting of the motor on restoration of voltage may result in injury to any person or persons, low-voltage protection shall be furnished.

Exception: When the motor and driven machinery are isolated and accessible to qualified persons only, the provision of a disconnecting switch eliminates the hazard to persons.

Order 1310.05. Disconnecting Means.

It is not the intent of this order to prohibit the disconnecting means from being in the same inclosure with the controller.

a. Except as provided below, every motor shall have an individual manually operable disconnecting means. Such individual disconnecting means need not be provided in the following cases:

1. For a portable motor not larger than ¼ horsepower having an approved attachment plug and receptacle for its controller. (See 1310.04–e–3.)

2. For a motor not larger than ⅛ horsepower for which the controller is the branch circuit overcurrent protective device. (See 1310.04–e–4.)

3. Omitted.

4. In the following cases a single disconnecting means may serve a group of motors.

x. Motors which drive the several parts of a single machine or apparatus such as metal and woodworking machines, etc., or such as cranes and hoists, see Section 133.0.

y. Groups of motors under the protection of one set of automatic overcurrent protective devices, as permitted elsewhere in this code.

z. Groups of motors in a single room and within sight of the disconnecting means.

b. The disconnecting means shall be of the indicating type and when open shall disconnect both the controller and the motor from all ungrounded supply conductors.

c. 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.

d. Except as provided below in this paragraph, the disconnecting means shall be a motor-circuit switch or a manually operable circuit-breaker. For motors rated two 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 ampere rating of the motor. For motors above 50 horsepower, the disconnecting means may be a general-use switch or an isolating switch. For a portable motor, an approved attachment plug and receptacle may serve as the disconnecting means.

e. The disconnecting means shall be located within sight of the controller or be arranged to be locked in the open position.

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

Order 1310.06. Grounding.

a. Generator frames shall be grounded in the manner specified in Section 103 of this code if the generator operates at a terminal voltage in excess of 150 volts to ground. Where the frame is not grounded, it shall be permanently and effectively insulated from ground.

b. Motor frames, except for portable motors, shall be grounded if the motor operates in excess of 150 volts to ground. Where the frame is not grounded it shall be permanently and effectively insulated from ground. The frames of portable motors which operate at more than 150 volts to ground shall be guarded or grounded.

It is recommended that the frames of motors which operate at less than 150 volts to ground be grounded when this can be readily accomplished.

c. Controller cases shall be grounded as required by Section 103 of this code.

SECTION 131.1. TRANSFORMERS AND CAPACITORS. (STATIC CONDENSERS) NOT OVER 600 VOLTS. No Winding of Which is Connected to a System Operating Over 600 Volts Between Wires or From Wire to Ground

Order 1311.01. Exception.

a. Nothing in this section shall be construed to apply to radio (See Section 133.7) nor to apparatus or fittings, the operation of which depends either wholly or in part upon special air-cooled transformers or capacitors used in connection with apparatus or fittings, but such apparatus or fittings shall satisfy the provisions of Section 131.7 of this Code.

Order 1311.02. General.

a. Oil-filled transformers may be installed in, outside and adjacent to, or attached to buildings by permission of the inspection department. When installed in a building they shall be contained in an inclosure of fire-resistive material not communicating with the building, except through openings closed by means of approved tight-fitting fire doors. The inclosure shall also satisfy the several provisions of Order 1350.06 of this code, provided, however, that this requirement for an inclosure may be waived if the rating of the transformer is not over seven and one-half k. v. a. and there is no combustible material in its vicinity. When attached to a building they shall be separated therefrom by substantial supports. When attached to or installed outside and adjacent to a building, they shall be placed against blank masonry or non-combustible walls away from all wall openings and so placed as not to expose combustible attachments, such as eaves, cornices, or porches.

Exception: The requirements of this order with regard to location of oil filled transformers shall not apply to apparatus or fittings, the operation of which depends either wholly or in part on special transformers embodied in the devices, or auto transformers used in connection with motor starters, but all such apparatus or fittings shall comply with these orders in all other respects.

b. The construction of an air-cooled transformer shall be such that when mounted on a plane surface the casing will make contact with such surface only at the points of support providing elsewhere an air space of at least ¼ inch between casing and surface. If the surface is composed of combustible material, the air space shall be increased to at least 1 foot, unless a slab of non-combustible, non-absorptive insulating material is interposed.

This will require a slab of slate, marble or soapstone, etc. somewhat larger than the transformer.

c. The foregoing paragraph, b, shall not be construed to apply to door-bell and other signaling transformers having the limitations outlined in sub-paragraphs 1 to 4, inclusive, of sub-paragraph y, of paragraph a of Order 1360.01 of this code and which operate at a primary voltage not exceeding 250 volts, nor to current transformers for metering or for protective relays.

d. Oil-filled capacitors for not over 600 volts shall comply with the requirements of Order 1350.08 of Section 135.0 of this Code.

e. Transformer and capacitor cases shall be grounded as provided in Section 103.

f. Each transformer shall be provided with a name-plate giving the maker's name, the rating in kilo-volt-amperes, the primary and secondary voltage ratings, the frequency and the oil capacity (if of the oil-filled type) in gallons. Each capacitor for power-factor correction shall be provided with a plate giving the maker's name and the capacity, voltage and frequency.

g. Capacitors and capacitor-transformer units used with individual A. C. motors for improving starting conditions and/or improvement of power-factor during normal operation shall be provided with a plate giving the maker's name and identification symbol, which symbol shall also appear on the name-plate of the motor with which the device is to be used.

SECTION 131.2. SWITCHES.

Order 1312.01. Knife Switches.

a. The minimum spacings and break distances are to be as specified in Tables 1 and 2 of paragraph a, of Order 1312.01, of the 1930 edition of this code.

These spacings and break distances are not intended to be applied to inclosed switches.

b. General-use knife switches shall not exceed a capacity of 1200 amperes for switches of 250 volts or less and 600 amperes for switches of 251 to 600 volts.

c. Switches rated above 600 amperes and therefore exceeding the capacities of standard sizes of cartridge inclosed

fuses, may be arranged for fuses in multiple, provided as few fuses as possible are used and the fuses are of equal capacity and are mounted so as to eliminate a potential difference between the multiple terminals.

d. Auxiliary contacts of a renewable or quick-break type or the equivalent shall be provided on all 600-volt 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 1312.02. Installation of Switches—General.

For hazardous locations See Section 133.2 of this Code.

a. Switches or manual circuit-breakers shall not be placed where exposed to mechanical injury, nor in the immediate vicinity of easily ignitible material. When the above conditions cannot be complied with, switches, circuit-breakers, and similar devices, unless of the oil-immersed type, shall be inclosed in approved metal boxes or cabinets. and shall be of the externally operable type.

b. Except as provided in the following paragraph, switches or manually operated circuit-breakers shall be placed only in dry, accessible places and be grouped so far as possible.

c. Switches or manually operated circuit-breakers, when located where exposed to moisture, as in basements and in similar places, shall be mounted in approved boxes or cabinets, and when located in wet places or outside buildings, shall be mounted in approved weatherproof switch boxes or cabinets.

d. Inclosures for switches or circuit-breakers on circuits, any wire of which operates at over 150 volts to ground, except where accessible only to qualified operators, shall be grounded as provided in Section 103 of this Code.

e. All switches shall be of the inclosed type externally operable except where accessible only to qualified persons.

f. Where switches are required.

1. Suitable switches or other disconnecting devices shall be installed in all circuits to make possible the independent disconnection of all utilization equipment from the source of supply, except as otherwise provided for in this code.

2. Switches shall be so placed in feeder conductors supplying panelboards that each panelboard may be independently disconnected from the source of supply.

Exceptions: (1) Such switches will not be required if the panelboards are equipped with switches for disconnecting individual branch circuits or groups of branch circuits from their supply circuit.

(2) If the installation comprises only one panelboard the service switch may serve as the disconnecting switch for the panelboard.

Note: Two panelboards placed adjacent to each other will be considered the same as a single panelboard.

(3) Panelboards supplying emergency lighting (stair and exit lights) are exempted.

Note: It is not desirable to subdivide control of the wiring for emergency lighting.

3. Switches shall be provided as necessary to make possible the independent disconnection of all fuses from the source of electrical supply before being handled.

Exception: It will not be required that such switches be located within sight of the fuses to be disconnected from the source of supply.

Note: The intent of this order is to require an individual switch or other disconnecting means to disconnect each set of cartridge fuses.

4. Switches or plug connectors shall be installed to permit the disconnection of temporary wiring or portable conductors from permanent or fixed wiring.

Note: See Order 1310.03(d).

g. When controlling circuits of capacities greater than 15 amperes, switches shall be so located or marked as to indicate their function, the location and character of equipment controlled by them and whether they are open or closed.

h. Switches to be capable of opening under load.

(1) Switches shall preferably be capable of breaking 150 per cent of the full load current of the connected apparatus at the rated voltage. (See Order 1310.03d)

(2) If switches are not capable of breaking 150 per cent of the full load current as required above, they shall be so located that they are not accessible to other than qualified persons.

i. When the disconnecting switch required by (f–1) above is accessible to other than qualified persons, the motor starter, including switches used as starters, shall be equipped with under or low-voltage protection.

Exception. Motors of one-fourth horsepower or less need not have their starters so equipped. See Order 1310.04–l.

j. Means shall be provided so that switches for disconnecting motors, storage batteries, transformers, electric furnaces, and similar utilization equipment can be locked in the open position to prevent careless closing while work

is being done on the equipment controlled by them. (See Order 1310.03 d and e)

Exception: (1) Small capacity snap or push switches, and push buttons of remote control switches if near machines and in plain sight from all parts of the machines controlled are exempted.

(2) Switches of any size are exempted if the installation comprises only one motor, and the switch is in plain sight from all parts of the machines operated by the motor.

(3) Open switches in rooms made inaccessible to other than qualified persons may be arranged to be blocked in the open position and plainly tagged. (See Order 1301.)

k. Disconnectors shall be accessible only to properly qualified persons. They shall also be protected by signs warning against opening the disconnectors while carrying current.

Order 1312.03. Position and Connection of Knife Switches.

a. 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, so constructed as to insure the blades remaining in the open position when so set.

b. When practicable, exposed knife switches shall be so wired that blades will be dead when the switch is open.

Order 1312.04. Number of Poles Required for Switches and Circuit-Breakers.

a. No switch shall be installed in the grounded conductor of a circuit unless the switch simultaneously disconnects the ungrounded conductor or conductors or unless the switch is so arranged that the grounded conductor cannot be disconnected until the ungrounded conductor or conductors have first been disconnected.

b. Three-way and four-way switches shall be classed as single pole switches and shall be so wired that only one pole of the circuit will be carried to the switch.

c. When a circuit-breaker serves as a switch it shall satisfy all applicable provisions of this code, according to the use, as to the number of poles.

Order 1312.05. Mounting of Snap Switches.

a. Sub-bases of suitable insulating material, which will separate the wires at least ½ inch from the surface wired over, shall be installed under all snap switches used in open work. Sub-bases shall also be used in wooden raceway work; but they may be made of hardwood or they may be omitted if the switch is approved for mounting directly on the moulding.

b. Flush Switches—(Snap or Push). Where flush switches or receptacles are used, whether with conduit or not, they shall be inclosed in a box constructed of iron or steel, in addition to the insulated inclosure of the switch or receptacle.

c. Support of Surface Snap Switches in Concealed Wiring. Switches shall be supported at outlets by approved fittings or outlet boxes giving proper support or by 3x⅞ inch block fastened between studs. When this cannot be done, base blocks not less than ¾ inch in thickness securely screwed to the lathing shall be provided.

Order 1312.06. Special Types of Switches.

a. Time switches, sign flashers and similar appliances shall be of approved design and inclosed in approved cabinets.

Note: In wet places the provisions of 1312.02-c must be observed and weatherproof cases provided.

Order 1312.07. Marking.

a. Switches shall be marked with the current and voltage for which they are designed.

SECTION 131.3. SWITCHBOARDS AND PANELBOARDS

This section does not apply to switchboards or portions thereof used exclusively to control signal circuits operated by batteries, but does apply to the charging panels where current is taken from light or power circuits.

For special provisions for hazardous locations see Section 133.2.

Order 1313.01. Switchboards: Location and Accessibility.

a. Switchboards shall be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

b. Switchboards shall not be built up to a non-fireproof ceiling, a space of 3 feet being left, if possible, between the ceiling and the board. The space back of the board shall be kept clear of rubbish and shall not be used for storage.

c. Switchboards shall be accessible from all sides when the connections are on the back.

It is recommended that all switchboards be set out from the wall, but they may be placed against a brick or stone wall when the wiring is entirely on the face.

d. Switchboards shall be so located that they will not be exposed to moisture.

e. Switchboard frames and structures supporting switching equipment shall be grounded, except that the frames for d-c single-polarity switchboards may be insulated for the full voltage of the circuit in lieu of grounding.

Order 1313.02. Switchboards: Material and Wiring.

a. The bases of switchboards shall be made of non-combustible material.

b. Busbars, if rigidly mounted, may be of bare metal.

c. If the wiring is on the back and is accessible only from the back of the switchboard, there shall be a clear space of at least 18 inches between the wall and the apparatus on the rear of board.

d. Insulated conductors where closely grouped as in rear of switchboards shall each have a flame-retarding outer covering.

e. Covering shall be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used.

f. Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils (except where the operation of the protective device might introduce a hazard in the operation of devices, or when the switchboard is inaccessible to other than qualified persons) shall be supplied by a circuit that is protected by standard automatic overcurrent protective devices of a rating not larger than 15 amperes except that for ratings of two amperes or less special inclosed types of fuses may be used.

g. Instruments, meters and relays mounted on switchboards, shall comply with the requirements of Order 1187 unless inaccessible to other than qualified persons, in which case the following requirements may be followed in lieu thereof;

For alternating-current circuits:

(1) The secondary circuits of current and potential instrument transformers shall be grounded.

(2) Instrument, meter and relay cases (whether operated from current and potential transformers, or connected directly in the primary circuit) on switchboards having no live parts on the front of the panels shall be grounded, where operating with current-carrying parts not exceeding 750 volts to ground.

(3) Instrument, meter and relay cases (whether operated from current and potential transformers or connected directly in the primary circuit) on switchboards having live parts on front of panels shall not be grounded where operating with current-carrying parts not exceeding 750 volts to ground. Rubber mats, or other suitable floor insulation, shall be provided for the operator if the voltage to ground exceeds 150.

(4) Instrument, meter and relay cases on circuits, exceeding 750 volts to ground shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or guards.

For direct-current circuits:

Instrument, meter and relay cases shall not be grounded. If the voltage of the circuit is less than 750 volts but above 150 volts to ground, rubber mats or other suitable floor insulation shall be provided for the operator. If the voltage to ground exceeds 750 volts, cases shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or by guards.

h. The conductors of remote-control switch circuits will be considered as suitably protected by fuses rated at not more than 750% of the carrying capacity of the conductors as given in Order 1306.12 of Section 130.6.

i. Switchboards which have any exposed live parts above 150 volts to ground (or live parts on ungrounded circuits exposed to a higher voltage to ground) shall be located only where under competent supervision and accessible only to qualified persons.

For switchboards having exposed live parts of lower voltages, see Orders 1304.05, 1308.05 and 1312.02.

Order 1313.03. Panelboards.

a. The requirements of this order shall apply to all panel and distributing boards used for the control of light and power circuits, but not to such switchboards in central stations, substations or isolated plants as directly control energy derived from generators or transforming devices.

b. Switches, fuses and cutout bases used on panelboards, shall conform to the requirements of Sections 131.2 and 130.8, respectively, of this code, so far as they apply.

c. In the relative arrangement of cartridge fuses and switches the fuses shall be placed on the load side of the switches except in the case of services, where the requirements of Section 130.4 shall be observed. Branch switches

shall be so arranged that the blades, if exposed during operation, will be dead when the switches are open.

d. When there are exposed live metal parts on the back of board, a space of at least ½ inch shall be provided between such live metal parts and the cabinet in which the board is mounted.

e. The following minimum distances between bare live metal parts (busbars, etc.) shall be maintained:

Between parts of opposite polarity except at switches and circuit-breakers.

When mounted on the same surface	When held free in air
Not over 125 volts ¾ inch	½ inch
Not over 250 volts 1¼ inch	¾ inch
Not over 600 volts 2 inch	1 inch

At switches, inclosed fuses, etc., parts of the same polarity may be placed as close together as convenience in handling will allow.

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.

f. Panelboards so installed as to be exposed to excessive moisture shall be inclosed in approved weatherproof cabinets.

g. Panelboards and cut-out bases for lighting distribution centers shall be inclosed in metal cabinets and the combination of cabinet and inclosed device shall be of such design as to be dead-front. A device is considered to be dead-front if it is so designed as to allow the replacement of fuses and the operation of switches without the possibility of unqualified persons coming in contact with live parts.

Note: 1. The term panelboard is clearly defined in definition of order 1020. While this definition speaks of a single panel it is understood that it also covers a group of panel units specifically designed for assemblage in the form of a single panel. Strictly speaking, porcelain cutouts in a cabinet are not considered panelboards but since such cutouts serve the same purpose it is clearly the intent of the code that the orders applied to panelboards shall also apply to cutouts insofar as this is practicable.

2. The mounting of an open knife switch in the feeder of a dead front panel of the "door within a door" type cabinet, provided such switch is installed behind locked door and accessible only to qualified persons, should be approved under this order.

h. The number of circuits of a lighting branch-circuit panelboard installed in any one section of a cabinet shall not exceed 42 where one automatic overcurrent protective

device per circuit is used or 20 where two automatic overcurrent protective devices per circuit are used.

SECTION 131.4. FIXTURES, LAMP-HOLDING DEVICES, PLUG RECEPTACLES AND OTHER OUTLET DEVICES

For special provisions for hazardous locations see Section 133.2.

Order 1314.01. Construction of Lighting Fixtures.

a. Fixtures shall be composed of metal or wood, or such other material as may have been submitted for examination and approved. Materials other than metal shall be re-enforced by metal or the fixtures shall be otherwise constructed to secure the requisite mechanical strength.

b. 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. This requirement shall not apply to portable table or floor lamps nor to wireways in glass, marble or similar non-absorptive insulating materials.

c. All methods of fastening arms, sockets, bodies, supports and receptacles by threading, soldering, brazing or otherwise, shall be such as to secure in every case ample strength and reliability, and to prevent turning. Screw joints shall have not less than five threads engaging. Tubing used in making threaded arms and stems shall be composed of metal having a thickness not less than .040 inch. It shall not be kinked, flattened or cracked.

d. All burrs and fins in wire-ways shall be removed and all sharp edges rounded, where practicable, so that wires may be drawn in and withdrawn without injury. Fittings having smooth, rounded edges shall be placed at entrance to casings of fixture stems.

e. Fixtures exposed to moisture, whether located indoors or outdoors, shall be so constructed that water cannot enter or accumulate in the wire-ways, lamp holders or other electrical parts.

f. Fixture studs which are not parts of outlet boxes, hickeys, tripods, and crowfeet shall be made of steel, malleable iron or other approved material.

g. Canopies and outlet boxes shall, taken together, provide ample space for the reception of the wires and their connecting devices.

h. Receptacles having exposed terminals shall not be placed in canopies unless completely inclosed in metal.

i. Canopy insulators, used where insulating joints are required, shall be of approved type and shall be securely fastened in place, so as to separate the canopies effectively and permanently from the conducting surfaces from which they are intended to be insulated.

A strip of good grade of hard fiber, 1/16 inch in thickness, securely attached to the canopy at the ends and at intermediate points in such a manner that the strip will extend at least 3/16 inch beyond the upper edge of the canopy rim, will be accepted. Where this is impracticable, a flat sheet of such fiber, cut to conform to the general outline of the canopy and having the edges of the sheet at least flush with the edges of the canopy, may be employed, if permanently attached to the canopy.

j. 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.

Order 1314.02. Wiring of Lighting Fixtures.

a. No conductor shall be smaller than No. 18. On chains or other movable parts stranded conductors shall be used, unless the wires are completely inclosed in metal. Where the fixture is externally wired, wires shall be secured in a manner which will not tend to cut or abrade the insulation, and shall be protected from abrasion where they pass through sheet-metal pans, canopies, etc. No splice or tap shall be located within an arm or a stem.

b. Each fixture shall be so wired that all screw shells of lamp holders are connected to the same fixture stem wire or supply wire or terminal. A fixture stem wire or supply wire connected to the screw shells of lamp holders shall be identified by means of a white or natural gray covering, or by means of a tracer thread contrasting with the color of the covering. In fixtures having wire-ways of such size that it is impracticable to pull in separate conductors without injury to the insulation, the identification may consist of a band of paint contrasting with the color of the covering and located as near as possible to the point where the wire leaves the fixture and at all conductor terminals which are connected to sockets. If a white or natural gray covering is employed the covering of all other fixture stem or supply wires in the fixture shall be of a contrasting color. If a tracer thread is employed there shall be no such thread in the covering of any other fixture stem or supply wire. A terminal attached to the screw shells of sockets shall be marked in the manner specified in paragraphs d to m of Order 1302.06 of this Code.

c. Chain fixtures shall be wired with flexible conductors so arranged that the weight of the fixture will not put tension on the conductor.

d. Except as provided below, fixtures in dry places and fixtures of raintight construction operating at not over 300 volts between conductors, shall be wired with one of the following types of conductors:

Fixture Wire—Type AF or CF.

Flexible Cord—Type AFC, AFPO, AFPD, CFC, CFPO or CFPD. Fixtures of a decorative type, on which lamps are used in connection with imitation candles may be wired with approved rubber covered conductors where lamps of not over 60 watt capacity are used on each candle. 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. Fixtures exposed to moisture that are not weathertight shall be wired with approved rubber-covered conductors. See Section 133.2 for Fixtures for use where gases may be present.

e. Fixture wires, or the individual conductors of flexible cords used where the voltage between any two conductors or between any conductor and the ground is over 300 volts. shall have insulation at least 3/64 inch in thickness for sizes No. 8 and smaller unless type S cord is used.

f. Wires of different systems shall not be contained in or attached to a fixture.

g. All wiring shall be free from short-circuits and grounds, and shall be tested for these defects prior to being connected to the circuit.

h. Fixtures, including lamp holders and lamp bases if within reach of grounded surfaces, shall be so designed and installed that no current-carrying parts will normally be exposed externally.

Order 1314.03. Installation of Lighting Fixtures.

a. Metal fixtures on circuits above 150 volts to ground and all metal electrical fixtures used with conduit, armored cable or metal raceways, not exempted from grounding elsewhere in this Code shall be grounded.

b. Fixtures used with knob-and-tube work, non-metallic sheathed cable or wooden raceways shall be grounded except as described below:

(1) Fixtures mounted on metal or metal lath ceilings or side walls may be insulated from their supports, and from the metal lath by the use of approved insulating joints or fixture supports and approved canopy insulators.

(2) Fixtures not mounted on metal or metal lath ceilings or side walls need be neither insulated nor grounded.

c. Gas piping to which fixtures are attached shall be grounded as provided for in Section 103, unless the fixtures are insulated therefrom or are grounded by one of the other means specified in the following paragraph. Gas piping need not be insulated from otherwise well-grounded fixtures. Combination gas and electric fixtures shall not be installed.

d. Fixtures shall be considered as grounded when mechanically connected in a permanent and effective manner to metal conduit, tubing, armored cable, a metal-raceway system, the grounding conductor of non-metallic sheathed cable, a separate grounding wire not smaller than No. 14, or to gas piping, which are grounded in the manner specified in Section 103 of this Code.

e. No externally wired fixtures shall be located in the immediate vicinity of specially flammable material; nor shall any externally wired fixture other than of the chain type be placed in a show window. Armored-cord pendants shall be considered to be internally wired fixtures.

f. Where a gas pipe, outlet box or other fitting which will provide proper support is required by this code or is present, the fixture shall be attached thereto; otherwise the fixture shall be attached to a wooden base block not less than ¾ inch in thickness supported independently of the screws supporting the fixtures. Fixture canopies used in lieu of covers at outlet boxes shall provide a continuous metal to metal fit (or equivalent) with the rim of the box whenever the wall or ceiling finish is of combustible material.

g. Gas pipes shall be covered with insulating tubing back of an insulating joint or blind hickey. Where outlet tubes are used they shall be of sufficient length to extend beyond the joint or hickey, and shall be firmly secured in place.

h. Fixtures shall be so installed that the connections between the fixtures, and the branch circuit wires will be easily accessible for inspection without requiring the disconnecting of any portion of the wiring, unless the fixture is attached by an approved plugging device.

Order 1314.04. Construction of Lamp-Holding Devices and Plug Receptacles.

a. Lamp-holding devices shall be classed according to diameters of lamp bases, as Candelabra, Intermediate, Medium and Mogul base, to be known respectively as ½ inch, 21/32 inch, 1 inch and 1½ inch nominal sizes, with ratings, as specified in the table following this paragraph. Switched lamp-holders shall be of such construction that the switching mechanism interrupts the electrical connection to the center contact. The switching mechanism shall not interrupt the electrical connection to the screw shell unless connection to the center contact is simultaneously interrupted.

Class	Nominal Diameter	Watts	Volts	Ratings Key Max. Amp. at any Voltage	Watts	Volts	Ratings Keyless 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
	(a)	660	250	6	660	600	----------
Mogul	1½ in.	----------	----------	----------	1500	250	----------
	(b)	----------	----------	----------	1500	600	----------

(a) This rating may be given only to sockets having a switch mechanism which produces both a quick "make" and a quick "break" action.

(b) Ratings to be assigned later, pending further discussion with manufacturers.

Miniature Sockets 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 Sockets and Receptacles see Section 134.0, Small Isolated Plants.

Receptacles for Attachment Plugs (Appliance and Convenience Outlets) are strongly recommended in order to facilitate the use of electrical appliances which, otherwise, must be connected to sockets designed primarily only for lamp holders.

If lamp holders must be used for the attachment of flexible cords they should be rated at 600 watts.

b. The inside of metal shells shall be lined with insulating material, which shall absolutely prevent the shell from becoming a part of the circuit, even though the wires inside the sockets should become loosened or detached from their position under the terminal screws.

c. 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 socket.

d. The cap also shall be lined.

In sockets and receptacles of standard forms a ring of any material inserted between an outer metal shell of the device, and the inner screw shell for insulating purposes and separable from the device as a whole, is considered an undesirable form of construction. This does not apply to the use of rings in lamp clusters or in devices where the outer shell is of porcelain or of moulded composition, where such rings serve to hold the several porcelain or composition parts together, and are thus a necessary part of the whole structure of the device.

e. The socket as a whole shall be so put together that parts will not rattle loose or fall apart under the most severe conditions they are likely to meet in practice. The base of the socket shall be secured or held in the shell in such a manner as to prevent turning or displacement relative to the shell.

f. Lead wires furnished as a part of weather-proof sockets and intended to be exposed after installation shall be of approved stranded, rubber-covered wire, not less than No. 14 gauge (No. 18 gauge for candelabra sockets), and shall be sealed in place or otherwise made raintight.

g. If the socket is not attached to a fixture, the inlet shall be equipped with an approved insulating bushing which if threaded, shall not be smaller than ⅜ inch in size. The edges of bushings shall be rounded and all inside fins removed in order to provide a smooth bearing surface for the wire.

It is recommended that bushings having holes 9/32 inch in diameter be employed with plain pendent cord, and holes 13/32 inch in diameter with re-enforced cord.

Order 1314.05. Installation of Lamp-Holding Devices and Plug Receptacles.

a. Sockets and receptacles installed over specially flammable material shall be of the keyless type and unless individual switches are provided, shall be located at least 7½ feet, above the floor, or shall be otherwise so located or guarded that the lamps cannot readily be backed out by hand.

b. When necessary to prevent portable lamps from coming into contact with flammable material, or to protect them from breakage, their flexible cord leads shall be equipped with handle, socket and substantial guard, the guard being securely attached to socket or handle.

c. Weatherproof sockets, specially approved for the location, shall be employed in damp or wet places or where

corrosive vapors exist. If not attached to fixtures or unless the provisions of Order 1303.06 of this code apply, medium or mogul base sockets shall be hung from separate stranded wires not less than No. 14, which are soldered directly to the circuit wires, but supported independently thereof. When intermediate or candelabra base sockets are installed in this manner the wires except for approved Christmas tree and decorative lighting outfits, shall not be smaller than No. 18.

It is recommended that these wires be twisted together if the pendant is longer than 3 feet.

d. Receptacles shall be supported in the same manner as specified for fixtures in Order 1314.03–f of this code.

e. Flush receptacles shall be inclosed in approved metal boxes in addition to the insulating inclosure of the receptacle mechanism.

f. Attachment plugs and receptacles located in floors shall be inclosed in approved metal boxes especially designed for the purpose. Where the location is free from mechanical injury or moisture, a departure from this requirement may be permitted by the authority enforcing this code.

g. Receptacles of the Edison-base type shall be installed only for use as lamp holders. Receptacles installed for the attachment of portable cords shall be of a type not suitable for use with Edison-base screw shells, and having no current carrying parts exposed.

h. Attachment plugs and receptacles shall be so designed and installed that plugs used on one voltage cannot be plugged into receptacles used on another voltage.

i. Pendent lights, portable lamp sockets, or lighting fixtures in bathrooms, basements, kitchens or damp and wet places or when within eight feet vertically, and/or five feet horizontally from any location where a person may touch or stand on grounded surfaces at the same time, shall be constructed of noncombustible, nonabsorbent insulating materials, if such parts are not permanently and effectively grounded. In bathrooms and kitchens, such lights shall be controlled by wall switches.

Order 1314.06. Rosettes.

a. When designed for use with exposed wiring, rosettes shall be provided with bases which shall have at least two holes for supporting screws, shall be high enough to keep the wires and terminals at least 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.

b. When 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.

c. Fuseless rosettes shall be rated at 660 watts, 250 volts, with a maximum current rating of 6 amperes.

d. Fused rosettes or separable rosettes which make possible a change in polarity shall not be installed.

SECTION 131.5. LAMPS

Order 1315.01. General.

a. The provisions of this section shall apply to lamps used on constant potential interior wiring systems and such outside lamps as may be connected thereto.

b. When installed in hazardous locations the appropriate provisions of Section 133.2 shall be observed.

c. Lamps shall be securely supported, and the hangar, rope, chain, or other means of support shall be regularly and systematically inspected. All metal cable or chain supports for lamps shall be effectively insulated from the lamp or shall be permanently grounded. Metal chains or metal cables and other conducting parts used for lowering lamps in series circuits shall be grounded or interrupted by a suitable strain insulator, the minimum height of which from the floor or ground shall be 8 feet whether the lamp is in position or lowered.

Order 1315.02. Arc Lamps.

a. Arc lamps shall be equipped only with such resistances or regulators as are inclosed in non-combustible cases, said resistances or regulators being treated as sources of heat. An incandescent lamp shall not be used as resistance or regulator. Economy and compensator coils shall be mounted on non-combustible, non-absorptive insulating supports, such as glass or porcelain, providing an air space of at least 1 inch between frame and support. Such coils shall generally be treated as sources of heat.

b. Arc lamps, except on grounded circuits of which no part exceeds 150 volts to ground, shall be effectively isolated or suitably guarded and all exposed metal parts grounded.

Isolation will ordinarily be deemed sufficient when a vertical clearance of 8 feet is provided from floors or other accessible places within buildings, of 10 feet from footways outside buildings, and of 15 feet from roadways. Horizontal clearance from windows, porches and other spaces accessible to the general public should be not less than 3 feet.

c. Leads subject to movement in raising or lowering of lamps shall have stranded conductors.

d. An automatic overcurrent protective device and a manually operable switch shall be provided for each ungrounded conductor supplying a lamp or series of lamps. A manually operable automatic overcurrent circuit-breaker may be used in place of both the protective device and the switch.

Order 1315.03. Mercury-Vapor Lamps.

a. Inclosed mercury-vapor lamps shall be equipped with only such resistance or regulators as are inclosed in non-combustible cases, such resistances or regulators being treated as sources of heat.

b. Exposed metal parts of such lamps or fixtures shall be grounded, as provided for equipment in Section 103 of this Code, if located where persons may easily touch grounded surfaces, at the same time as the exposed metal parts of lamps or fixtures.

Order 1315.04. Incandescent Lamps.

a. Incandescent lamps shall not be equipped with medium bases if above 250 watts rating nor with mogul bases if above 1500 watts. Above 1500 watts special approved bases or other devices shall be used.

b. Gas-filled incandescent lamps shall not be located in show windows, nor where liable to contact with flammable material, unless installed in approved fixtures equipped with shades or guards, or suitably designed to operate at a safe temperature.

Order 1315.05. Wiring to Lamps.

Wires connected to lamps shall have approved insulating coverings with heat-resisting qualities consistent with the temperature to be encountered. (See Section 130.6 of this Code.)

SECTION 131.6. ELECTRICAL APPLIANCES

Order 1316.01. General.

a. This article shall be construed to apply only to electrical appliances designed for domestic or general commercial use.

b. Each electrical 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.

It is recommended that the manufacture of portable appliances operating in excess of 150 volts for domestic purposes be discontinued, except for appliances rated at more than 1650 watts and for use on heavy-duty appliance branch circuits.

c. Individual heating elements, which are a part of an electric appliance containing more than one heating element, shall, in addition to the provisions of the foregoing paragraph, each be legibly marked with normal rating in volts and amperes, or in volts and watts.

Appliances rated at more than 1650 watts may be of higher voltage and/or capacity, in which case they shall be used on circuits of suitable design that have characteristics and protection against overcurrent, as provided elsewhere in this code.

Order 1316.02. Switch or Control Methods.

a. Each appliance rated at over 1650 watts shall be controlled by an indicating switch, not a part of the appliance, and which shall disconnect from the appliance all ungrounded conductors of its supply circuit or a single approved attachment plug and connector receptacle of appropriate rating may be used in lieu of a switch. The location of such control means shall be as follows:

(1) It shall be readily accessible to the operator of the appliance.

(2) In other than dwelling occupancies it shall control only the appliance.

(3) In multi-family (more than two) dwellings a switch shall be within the apartment or on the same floor as the apartment in which the appliance is installed and may control lights and other appliances.

(4) In two-family dwellings a switch may be outside of the apartment in which the appliance is installed but must be readily accessible. This will permit an individual service switch for the apartment to be used provided it is accessible to the user of the appliance.

(5) In single family dwellings the service switch may be used for this purpose.

Note: The switch may be mounted on the end of a range if it disconnects all ungrounded conductors.

b. Where the switch controls a motor-operated appliance, it shall be within sight of the appliance.

c. Switches controlling the individual units of electrical appliances shall not be considered as taking the place of the indicating controlling switch required in paragraph a of this order.

d. Each portable electrical appliance shall be equipped with an approved plug connector so designed that the plug may be pulled out to open the circuit without leaving any live parts so exposed as to render likely accidental contact therewith. The connector may be located at either end of the flexible conductor or inserted in the conductor itself.

See Section 133.2 for special types required in hazardous locations.

Order 1316.03. Wires Supplying Electrically Heated Appliances.

a. Wires supplying stationary electrically heated appliances shall be so located and/or installed as to be adequately protected from mechanical injury and moisture.

b. Where the surrounding temperature of fixed wires exceeds 120° F. (49° C.), types A or SB wires shall be used. In all other cases the type of insulation on fixed wires shall be that specified elsewhere in this code for the conditions which prevail.

c. Wires supplying smoothing irons and all other portable electrical heating appliances which are rated at more than 50 watts and which produce temperatures in excess of 250° F. (121° C.) on surfaces with which the wire is liable to be in contact, shall be approved heater cord, Types HC and HPD. For other portable electrical heating appliances approved lamp cord, Type C, or other cords especially approved for the purpose may be used.

Order 1316.04. Special Provisions for Electrically Heated Appliances.

a. Each electrically heated appliance which is obviously intended by size, weight and service to be secured in a fixed position shall be so placed as to furnish ample protection between the appliance and adjacent combustible material.

b. 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 device or may be a part of the appliance.

c. In other than residence occupancies each electrically heated appliance or group of electrically heated appliances intended to be applied to combustible material shall be in-

stalled in connection with an approved signal unless the appliance is provided with an approved integral temperature limiting device.

d. Subdivided circuits of electrically heated appliances need not be separately fused, but individual heating elements of such electrically heated appliances shall be fused if they are rated at more than 30 amperes.

e. Protection from Burns—Inclosure of Glowing Parts. Electric furnaces and apparatus used for arc welding, where intensely glowing incandescent or arcing parts are exposed shall be inclosed so that those parts will not be accessible to unqualified persons.

f. Screens, Hoods, Goggles.—Suitable protecting screens, hoods, goggles, gloves and other devices shall be provided for the qualified persons who must work or come near such exposed parts. (See National Safety Code for the Protection of the Heads and Eyes of Industrial Works, A. E. S. C. X_2, for mechanical and optical protection.)

Order 1316.05. Immersion Type Electrical Heaters.

a. Electrical heaters of the portable immersion type shall be so constructed and installed that current carrying parts are effectively insulated from electrical contact with the liquid or material being heated. The authority enforcing this code may make exception of special applications of apparatus where suitable precautionary measures are followed.

b. Portable immersion type heaters shall be equipped with approved connectors or with switch which will disconnect heater from the supply circuit.

Order 1316.06. Grounding.

(a) 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 103 of this Code; provided, however, that where this is impracticable, grounding may be omitted by permission of the authority enforcing this code, in which case the frames shall be permanently and effectively insulated from the ground.

It is recommended that the frames be grounded in all cases.

SECTION 131.7. RESISTORS; REACTORS AND CAPACITORS

(Static Condensers)

For hazardous locations, see Section 133.2 of this Code.

Order 1317.01. Construction.

a. Rheostats, resistance boxes and equalizers shall be of approved types.

b. Reactance coils shall be composed of non-combustible material mounted on non-combustible bases and treated generally as sources of heat.

c. Capacitors shall be provided with non-combustible cases and supports, and shall be installed in the manner provided for other apparatus operating with equivalent voltages and currents.

d. Resistance devices shall be so constructed that when mounted on a plane surface the casing will make contact with such surface only at the points of support, an air space of at least ¼ inch being maintained between the casing and the surface.

e. The terminals of motor-starting rheostats shall be marked to indicate the part of the circuit to which each terminal is to be connected as "line," "armature" and "field."

f. Fixed and movable contacts shall be so designed and so connected to the resistive conductor that there will be a minimum of arcing and consequent roughening of the contacts, even with careless handling or in the presence of dirt. In motor-starting rheostats, the point or plate on which the arm rests when in the starting position shall have no electrical connection with the resistive conductor.

g. Motor-starting rheostats shall be so designed that the contact arms cannot be left on intermediate segments. Such rheostats, if intended for use on direct-current circuits, 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.

h. Where insulated wire is used for connections between resistance elements and the contact device of a rheostat, except for motor-starting service, the insulation shall be asbestos-covered, Type A, or of the slow-burning (SB) type.

Order 1317.02. Installation.

a. Resistance devices shall be placed on a switchboard, or at a distance of at least 1 foot from combustible material, or shall be separated therefrom by a slab or panel of non-combustible, non-absorptive material, such as slate,

soapstone or marble. This slab shall be somewhat larger in area than the resistance device and shall be secured in position by its own supports which shall be independent of those fastening the resistance device to the slab. Bolts which support the resistance device shall be counter-sunk at least 1/8 inch below the rear surface of the slab and shall be covered with insulating material. The slab shall have a thickness proportioned to the size and weight of the resistance device, in order to provide proper mechanical strength, and this thickness shall be not less than 1/2 inch.

b. Resistors, reactors and capacitors shall not be placed where exposed to mechanical injury or in the immediate vicinity of easily ignitible material. When these conditions cannot be complied with, the device, unless of the oil-immersed type, shall be inclosed in approved metal boxes or cabinets.

c. Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided they do not carry or control the main current nor constitute the regulating resistance of the device.

d. Lamps, when used as resistance, shall be mounted in porcelain receptacles attached to non-combustible supports and shall be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated. They shall in all cases be provided with a nameplate, which shall be permanently attached beside the receptacle or receptacles and shall be stamped with the wattage and voltage of the lamp or resistor to be used in each receptacle.

e. Incandescent lamps may be used for the purpose of resistances in series with other devices, by permission of the authority enforcing this code and when mounted in porcelain receptacles upon non-combustible supports and when so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated.

SECTION 131.8. STORAGE BATTERIES

Order 1318.01. General.

a. The provisions of this section are intended to apply to all stationary installations of storage batteries using acid or alkali as electrolyte, consisting of a number of cells connected in series with a nominal potential in excess of 16 volts, and connected for service where so installed.

b. Nominal battery potential shall be calculated on the basis of 2.0 volts per cell for lead-acid type, and 1.2 volts per cell for alkali type.

c. Wiring and appliances, except as provided in Section 136.0 of this code, supplied with current from such storage battery installations shall be subject to the general requirements of this code applying to wiring and appliances fed from generators developing the same difference of potential.

Order 1318.02. Battery Rooms.

a. 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.

b. Wiring shall be inclosed in a non-corrodible or suitably protected conduit system, or shall be exposed and installed in accordance with the requirements of Order 1305.01 of this code, except that in battery rooms varnished cloth or tape insulated conductors shall not be permitted, and except that bare conductors may be used in the battery room when properly supported. Where metallic conduit or 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 such metallic conduit or covering and shall be bushed by a substantial glazed insulating bushing, and the end of the conduit or covering shall be sealed tightly to resist the entrance of electrolyte by spray or by creepage. Rubber insulating tape or other suitable material shall be used for this purpose.

Order 1318.03. Batteries—Not Over 250 Volts (Nominal) Potential.

a. Cells in series circuit, not over 250 volts shall be subject to the following provisions for additional insulation.

b. Cells in lead lined wood tanks, not over 50 volts series circuit, shall be supported individually on glass or glazed porcelain insulators; over 50 volts, on oil insulators.

c. Cells of the alkali type in jars made of conducting material shall be installed in trays of non-conducting material, with not over 24 volts in series circuit in any one such tray; or the cells may be supported singly or in groups on porcelain or other suitable insulators.

d. Cells in unsealed jars made of non-conducting material shall be assembled in trays of glass or supported on glass or glazed porcelain insulators; or, when installed on a rack

shall be supported singly or in groups on glass or other suitable insulating members.

e. Cells in sealed rubber or composition containers, shall require no additional support or insulation when not over 150 volts in series circuit; when the total voltage is over 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. When trays or racks are used for this type of cell, whether required or not, such trays or racks shall be supported on glass or glazed porcelain insulators or oil type insulators.

f. Cells in sealed glass jars, with or without wood trays, shall require no additional insulation.

Order 1318.04. Batteries—Over 250 Volts (Nominal) Potential.

a. The installation of cells of any type shall conform to the requirements of Order 1318.03 and in addition shall be installed, in groups of 250 volts or less, in trays or on racks supported on oil insulators; except that if all individual cells or sub-groups in the tray or rack are 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 with not more than 250 volts in series circuit; each such tray to be supported on glass or glazed porcelain insulators, the trays being mounted on racks supported on oil insulators with not over 500 volts in series circuit on each such insulated rack.

Maximum protection is secured by sectionalizing high voltage batteries into cell groups insulated from each other.

Order 1318.05. Racks and Trays.

a. Racks, as specified in this section, refer to frames designed to support cells or trays. They shall be substantial and made of:

1. Wood racks so treated as to be resistant to deteriorating action by the electrolyte; or
2. Metallic racks so treated as to be resistant to deteriorating action by electrolyte and provided with non-conducting members for the support of the battery; or
3. Other similar suitable construction.

b. Trays refer to frames such as crates or shallow boxes usually of wood or other non-conducting material so treated as to be resistant to deteriorating action by the electrolyte.

SECTION 131.9. LIGHTNING ARRESTERS.

Order 1319.01. In Industrial Stations.

a. Where adequate protection against lightning is not otherwise provided, lightning arresters shall be connected to each ungrounded overhead wire entering or leaving an industrial station on the line side of all connected station apparatus. In the case of more than one line, a single arrester equipment may be installed on the station bus, where suitable means are provided to protect lines that may remain disconnected from the bus.

b. Arresters may be installed indoors if located well away from other equipment, passageways, and combustible parts of the building. When located in buildings, lightning arresters containing oil shall be separated from other equipment by fire walls adequate to completely isolate them in case of fire.

c. When located outdoors, lightning arresters containing oil shall be arranged to drain away any oil that may be spilled.

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.

d. Choke coils are not required but if used shall be installed between the lightning arrester tap and the apparatus to be protected.

e. The connections from the line to the arrester and from the arrester to the ground shall be made as short and straight as practicable, avoiding as far as possible all bends and turns, especially sharp bends.

f. The connection between arrester and line wire or bus and between arrester and ground shall be of copper wire or cable, or equivalent, and shall not be smaller than No. 6.

g. All accessories of the lightning protection equipment such as gap electrodes, and choke coils if used, shall have an insulation from ground or other conductor at least equal to the insulation required at other points of the circuit.

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

i. Lightning arresters shall be grounded as provided in Section 103 of this code.

Order 1319.02. Radio Equipment.

See Section 133.7 of this code.

Order 1319.03. Signal Systems.

See Section 136.0 of this code.

Order 1319.04. Grounding.

See Section 103 of this code.

SECTION 132.0. WIRING INSTALLATION DESIGN

A Lighting Outlet is defined as an outlet intended for the direct connection (otherwise than by a portable cord) of a lighting fixture, a lampholder or a pendent cord terminating in a lampholder. A Receptacle Outlet is defined as an outlet equipped with one or more receptacles, not of the screw shell type, intended to receive attachment plugs.

Order 1320.01. Polarity Identification of Systems and Circuits.

a. All interior wiring systems shall have such an arrangement of conductors that systematic polarization, protective grounding and connection to service may be readily accomplished; and each lighting and/or appliance branch circuit shall contain one wire which is continuously identified, grounded, and connected to each lamp or appliance on the circuit. This is possible only with the following recognized grounded systems and circuits with the grounded wire continuously identified.

1. A two-wire system, one wire of which is continuously identified.

2. A three-wire direct-current or a three-wire single-phase alternating-current system, the neutral wire of which is continuously identified.

3. Other multiple-wire systems having one wire continuously identified.

Exception 1. Unidentified two-wire branches tapped from the outside wires of (a) an identified three-wire direct-current circuit, (b) an identified three-wire alternating current circuit, or (c) a multiple-wire alternating-current circuit having an identified neutral, and located within the same premises, will be permitted if no fuse is omitted, and no single-pole switches or sockets are used on lighting circuits.

Exception 2. By special permission of the authority enforcing this code, the following unidentified systems and circuits may be used:

(a) Grounded Systems and Circuits Without Identified Wire.

(1) A two-wire system or circuit supplied from the outside wires of a three-wire direct-current system or from a three-wire or multiple wire alternating-current system, having a neutral point grounded, but having no identified neutral wire within the system.

(2) A multiple-wire polyphase system or circuit with the neutral of one phase grounded.

(3) A multiple-wire polyphase system or circuit with the neutral point grounded, but having no identified neutral wire within the system.

(b) Ungrounded Systems and Circuits.

(1) Two-wire or multiple-wire systems and circuits not intended to be grounded.

b. Wiring systems and circuits derived from transformers in which a part of the turns are common to both primary and secondary alternating current circuits, ordinarily known as auto-transformers, shall not be permitted for any interior wiring system except as follows:

1. Unless the system supplied contains an identified grounded wire which is solidly connected to a similar identified grounded wire of the system supplying the auto-transformers.

2. Auto-transformers used for starting and controlling induction motors whether included in starter cases or installed as separate units.

3. For supplying circuits wholly within apparatus which also contains the auto-transformer.

4. Auto-transformers as fixed voltage adjustment on existing unidentified power circuits.

The intent of the above paragraphs is definitely to prohibit the use of auto-transformers as balance coils.

c. In any of the above systems no grounded wire shall have placed in it a switch or an automatic overcurrent protective device operating to open that wire unless all wires of the circuit are opened simultaneously. For exception, see Order 1320.03.

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

e. The polarized grounded wire of an interior wiring system shall be continuously identified throughout the system by the use of an identified outer covering, as specified in paragraph f of Order 1306.02 of this code, for rubber

covered wires No. 6 and smaller. For larger wires and wires of other than rubber-covering the identification shall be secured either with the white or natural grey outer covering, or by a distinctive marking at terminals during the process of installation.

f. Wires having white or natural grey covering shall not be used in identified systems or circuits other than as conductors for which identification is required by this order, unless the identified wire is rendered permanently unidentified by painting or other effective means at every outlet where the wires are visible and accessible, except that single-pole switch loops in circuits wired with armored cable, or with non-metallic sheathed cable may contain a white or natural grey conductor if the connections are so made that the return conductor from the switch to the outlet is black or a color other than white or natural grey.

The foregoing permits the use of two-wire cable having one black and one white wire on two-wire circuits tapped from the outside legs of a three-wire direct-current system or any two wires of a multi-wire alternating current system which are not identified if the identified wire of the two-wire cable is rendered permanently unidentified. The exception makes it unnecessary to paint the terminal of the white wire at a switch outlet.

g. Where pendants are attached to a wiring system containing an identified wire, that conductor of the flexible cord which is connected to the identified wire of the system shall itself be connected to the screw shell terminal of any lamp holder attached thereto.

It is recommended that flexible cords to portables be similarly identified and connected.

Order 1320.02. Branch Circuits—General Provisions.

a. Except as permitted in other sections of this code, every lamp, motor, electrically heated appliance and other device consuming electrical energy shall be supplied by a branch circuit of one of the types specified in the following orders of this section or in Section 130.8 of this code.

Order 1320.03. Automatic Overcurrent Protection of Branch Circuits.

a. All ungrounded wires of a branch circuit shall be protected by fuses or circuit-breakers. When the grounded conductor is identified and properly connected, branch circuits shall be protected in the ungrounded wires only, except that in locations where the conditions of grounding or the liability of the reversal of connections warrant, the in-

spection department may require, on systems having a grounded neutral or having one side grounded, that both wires of two-wire branch circuits shall be so protected.

Order 1320.04. Multiple-Wire Branch Circuits.

a. On systems having grounded neutrals the following branch circuits may be three-wire, direct-current or single-phase circuits, or four-wire, three-phase circuits;

15-ampere branch-circuit,

Mogul lamp-holder and mercury vapor-lamp branch circuits,

Appliance branch circuits.

b. Except as may be authorized in paragraph b of Order 1320.05 where such a multiple-wire branch circuit is employed, its neutral conductor shall be carried from the branch-circuit distribution center to the outlets and shall not be connected to the neutral of any other circuit except at the distribution center.

Order 1320.05. 15-Ampere Branch Circuits.

a. Fifteen-ampere branch circuits shall comply with the following:

1. Wires smaller than No. 14 shall not be used.
2. Automatic overcurrent protective devices shall have a rating or setting not exceeding 15 amperes at 125 volts or less and not exceeding 10 amperes at 250 volts.
3. Such a circuit may supply lighting outlets, receptacle outlets, or permanently connected appliances, or any desired combination of such loads but shall not be used to supply any appliance rated at more than 1320 watts. Except as permitted by Order 1320.10 of this section and except as permitted by other sections of this code, not more than 12 outlets shall be supplied through any ungrounded conductor of such a branch circuit.

At manual switchboards and on switching frames in telephone exchanges the number of outlets on a single branch circuit need not be limited.

b. A common neutral conductor may be employed for not more than eight 15-ampere branch-circuits on a three-wire direct-current or single-phase system or on a five-wire two-phase system, and for not more than six such circuits on a four-wire three-phase system. Such a common neutral conductor shall have a carrying capacity at least sufficient for the current corresponding to the condition of maximum possible unbalance. In any group of circuits having a

common neutral the same number of circuits shall, as nearly as possible, be connected between the neutral conductor and each of the other conductors of the system and if the circuit conductors are installed in metal conduit or other metal inclosure, all conductors of the group shall be installed in the same inclosure.

Order 1320.06. Appliance Branch Circuits.

a. Appliance branch circuits shall comply with the following:

1. Wires smaller than No. 12 shall not be used.

2. Automatic overcurrent protective devices shall have a rating or setting not exceeding 25 amperes.

3. Appliance branch circuits shall supply only receptacle outlets fitted with receptacles rated at 15 amperes, or permanently connected appliances. No appliances rated at more than 15 amperes or 1650 watts shall be supplied by such a branch circuit.

4. One conductor of every appliance branch circuit shall be a grounded conductor and the voltage between the grounded conductor and any other conductor of the circuit shall not exceed 150.

Order 1320.07. Individual Appliance Branch Circuits.

a. Each electrically-heated appliance and each combination motor-driven and electrically-heated appliance rated at more than 15 amperes shall be supplied by an individual branch circuit. The subdivision of the load into units within a single appliance shall not be taken as a basis for determining the character of the circuit supplying an appliance in which the load is subdivided into two or more units.

Order 1320.08. Mogul Lamp-Holder and Mercury-Vapor Lamp Branch Circuits.

a. Mogul lamp-holder and mercury-vapor lamp branch circuits shall comply with the following:

1. Wires smaller than No. 12 shall not be used. The conductors shall be of such size as will be protected by the branch circuit overcurrent protective devices.

2. Except as provided in sub-paragraph 3 of this order, the branch circuit overcurrent protective devices shall have a rating or setting not exceeding 40 amperes at 125 volts or less, and not exceeding 20 amperes at 250 volts.

3. The branch circuit overcurrent protective devices may have higher ratings or settings than are permitted by the foregoing sub-paragraph 2 where a separate branch circuit supplies a group of mercury-vapor lamps not exceeding 4000 watts total capacity and the group of lamps is mounted on a single frame and is arranged for control of all lamps in the group by a single switch.

4. If the rating or setting of the overcurrent protective device exceeds 15 amperes, such a circuit shall supply only mogul lamp holders, mercury-vapor lamps, or both, except that lamp-holders of the medium-base type approved for this use may be connected to such a circuit where they are combined with one or more mercury-vapor lamps as integral parts of a single approved lighting fixture.

5. Except by special permission, not more than eight mogul lamp holders or mercury-vapor lamps and not more than a total of eight mogul lamp holders and mercury-vapor lamps shall be supplied through any ungrounded conductor of such a circuit.

b. On mogul lamp-holder and mercury-vapor lamp branch circuits, if the rating or setting of the overcurrent protective devices exceeds 15 amperes, the conductor used for connecting the circuit conductors to the lamp holders or lamps shall not be smaller than No. 14 and shall have a carrying capacity at least equal to the current corresponding to the load supplied. Conductors of the same size as permitted by the preceding portion of this paragraph may also be used for taps not over 18 inches long, leading from the circuit conductors to outlets at which lamp holders or fixtures are connected.

c. The preceding requirements of this Order shall also apply to gas-tube lamps having rated capacities of 300 watts or more, operating at 250 volts or less and having physical and electrical characteristics similar to those of mercury-vapor lamps.

Order 1320.09. Other Types of Branch Circuits and Special Requirements.

Festoon Lighting Circuits.

See Section 130.3.

Motor Branch Circuits.

See Section 130.8.

Circuits Supplying Stage Equipment.

See Section 133.6.

Circuits for Signs and Outline Lighting.

See Section 133.8.

Circuits Operating at 50 Volts or Less.

See Section 134.0.

Order 1320.10. Outlets and Areas per Circuit.

a. The limitation of 12 outlets per circuit shall be waived in residential occupancies provided that in addition to any appliance branch circuits at least one 15-ampere branch-circuit is installed for each 500 square feet of floor area. The floor area shall be computed from the outside dimensions of the house or apartment not including open porches, unfinished spaces in basements or attics and any garage accommodating not more than two cars.

It is recommended that house wiring installations be laid out on the basis of one branch circuit per 500 square feet of floor area in addition to the one or more appliance circuits installed.

b. In the space occupied by a single family the total number of outlets supplied by 15 ampere branch circuits shall, as nearly as possible, be equally divided among the circuits.

Order 1320.11. Demand Calculations for Feeder Sizes.

a. General and definitions.

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

1. This section discusses "estimated or calculated" demand factors rather than measured demand and corresponding demand factors according to the above definition.

2. For conciseness the calculated demand factor will be referred to hereafter in this section as the "demand".

3. The demand values given in the following paragraphs of this section are those percentages of the total load upon the conductors as computed on the basis of watts for the area and the occupancy, and which may reasonably be expected under the conditions indicated.

4. The word "Area" means gross area, which will be determined by the outside dimensions of the building and by the number of floors. Unoccupied cellars, unfinished attics, and open porches need not be included in this computation.

5. All conductors of an interior wiring system, also including overhead service conductors between the service head and the service switch, and underground conductors between buildings under one ownership or management, mains, feeders and sub-feeders, up to the final distributing center, are referred to herein as feeders.

b. Scope and application.

It is the intent of this code that the provisions of this section shall apply only when it is desired to install feeder conductors of capacities smaller than are called for on the basis of the current required to supply the total connected load.

Voltage drop due to length of feeders has not been considered. However, it is recommended that the outside feeder conductors shall be of such size as to cause not more than 3% voltage drop up to the final distributing point on any feeder after the demand, if any, has been applied.

1. This rule applies to an interior wiring system which supplies both lights and appliances on the same circuits, but does not include capacity for industrial or other apparatus requiring special circuits. The calculation of current load for ranges is treated in item 18 of paragraph d of this order.

2. The values and demands given in this order are based on average load conditions. If at any time after the equipment is put in service it shall be found that the conductors are overloaded they shall be increased to comply with the requirements of the Table of Order 1306.12.

It is recommended that a diagram showing contemplated feeder details be furnished the authority enforcing this code as necessary advance information. This to show:

Area in square feet
Computed load
Demand selected
Load after applying demand
Sizes of conductors.

c. To determine the size of feeders that supply both light and power loads, the current in amperes for the lighting load shall be determined as specified herein, the current in amperes for the power load as specified in paragraph a of Order 1308.08 of this code, and the sum of these shall determine the size in accordance with Order 1306.12.

d. 1. The current load for lighting and appliances shall be determined in accordance with the following items and under conditions specified for each, unless the authority enforcing this code shall decide that conditions require larger sizes and shall specify the sizes to be used.

2. Current-carrying capacities to prevent overheating shall be determined in accordance with Order 1306.12.

3. The sizes of feeders shall be not smaller than as determined by the area supplied, multiplied by the "demand" values tabulated below representing the watts or fractions of a watt per unit of area for each kind of building and occupancy served.

TABLE OF REQUIRED MINIMUM WATTS PER UNIT AREA AND DEMAND FACTORS APPLYING THERETO

4. Buildings constructed and used for single family dwelling.

One watt per square foot, plus 1000 watts for appliances.

For area of 2000 or less square feet, demand 100 per cent for all excess over 2000 square feet, 60 per cent.

No demand shall be applied in connection with appliance loads.

5. Buildings constructed and used for multi-family dwellings (other than hotels):

One watt per square foot, plus 1000 watts per apartment for appliances.

For wattages of 2000 or less—demand 100 per cent.

For that part of the wattage in excess of the first 2000 watts a demand of 70 per cent, provided the number of apartments does not exceed ten. If the number of apartments is between 11 and 40, the second factor shall be 60 per cent. For 41 or more apartments, the second factor shall be 50 per cent. The demand for each feeder shall be determined in the same manner, i. e., by the area and the number of apartments supplied. Demands shall not be applied to appliance loads in computing size of sub-feeders to individual apartments. Demands may be applied to combined lighting and appliance loads in computing the sizes of mains and feeders other than sub-feeders to individual apartments.

6. Apartment Hotels (having provision for individual electric cooking):

One watt per square foot, plus 1000 watts per apartment for appliances.

For wattages of 2000 or less, demand 100 per cent.

For that part of the wattage in excess of 2000 watts, a demand of 70 per cent, provided the number of apartments does not exceed 10. If the number of apartments is between 11 and 40, the second factor shall be 60 per cent. For 41 or more apartments, the second factor shall be 50 per cent.

Demands shall not be applied to appliance loads in computing the sizes of sub-feeders to individual apartments. Demands may be applied to combined lighting and appliance loads in computing the sizes of mains and feeders other than the sub-feeders to individual apartments.

7. Hotels (having no provision for individual electric cooking).

One watt per square foot, except for the ballrooms.

For areas 10,000 square feet or less per feeder, demand 100 per cent.

For that part of the area in excess of 10,000 square feet and not more than 50,000 square feet per feeder, a demand of 80 per cent.

For the excess above 50,000 square feet per feeder, a demand of 70 per cent.

8. Stores and Department Stores (excluding Display Cases and Show-Window Lighting): Two watts per square foot.

To this shall be added an allowance for special display lighting as follows:

Counter Cases (silent salesmen): 25 watts per linear foot.

Wall or Standing Display Cases: 50 watts per linear foot.

Show Windows: See Item No. 9 below. Demand 100 per cent.

9. Show Windows: 200 watts per linear foot, measured horizontally along the base of the show window—demand 100 per cent.

Note: The term show window shall apply to any window used or designed to be used for displaying of goods or advertising material. The reasonable minimum requirements of this order shall, for adequacy in wiring, apply in all cases, whether the show window is fully or partly enclosed or entirely open at the rear, and whether or not it has a platform raised over the store floor level.

10. Office Buildings: 2 watts per square foot.

For areas 10,000 square feet or less per feeder—demand 100 per cent.

For all excess above 10,000 square feet per feeder—demand 70 per cent.

11. Industrial Commercial (Loft) Buildings: One watt per square foot—demand 100 per cent.

For the purpose of this section an industrial commercial building is defined as a building of more than one floor used for manufacturing or merchandising, occupied by more than one tenant.

12. Garages: ½ watt per square foot, exclusive of the machine shop or display rooms, if any—demand 100 per cent.

13. Hospitals (except in the operating suite and X-ray department): ¾ watt per square foot.

For areas of 25,000 square feet or less per feeder—demand 100 per cent.

For the excess area above 25,000 square feet per feeder—demand 60 per cent.

14. Schools: 1½ watts per square foot. For areas of 10,000 square feet or less per feeder—demand 100 per cent.

For the excess area above 10,000 square feet per feeder—demand 50 per cent.

15. Storage Warehouses: ¼ watt per square foot.

For areas of 50,000 square feet or less per feeder—demand 100 per cent.

For the excess area above 50,000 square feet per feeder—demand 50 per cent.

16. Factory Buildings: Feeder sizes shall be based on the specific load which they are to serve.

For the purpose of this section a factory is defined as a building or a portion of a building occupied by one tenant, which is used for manufacturing purposes.

17. Other Kinds of Buildings and Occupancies: Theatres, churches, and other places of public assemblage, ballrooms, dance halls, restaurants, club and lodge rooms, community centers, armories, libraries, operating suites and X-ray departments in hospitals, etc., and buildings for special purposes, such as banks, motion picture studios, etc., vary so widely due to geographical location, individual requirements, architectural and ornamental treatment that no standard has been established upon which the watts per square foot may be determined with accuracy. Therefore, the feeders for these and other buildings or occupancies not listed above, shall be determined by the specific load which they are to serve and as ordinarily computed. This applies also to special uses, such as flood and outline lighting, signs, etc.

18. Electrically Heated Cooking and Baking Appliances: The sizes of feeders supplying electrically heated cooking and baking appliances, each rated at more than 1650 watts, may be determined on the basis of the demand values shown in the following table:

Number Ranges	Demand Per Cent	Number Ranges	Demand Per Cent
1	80	14	41
2	75	15	40
3	70	16	39
4	66	17	38
5	62	18	37
6	59	19	36
7	56	20	35
8	53	21	34
9	51	22	33
10	49	23	32
11	47	24	31
12	45	25	30
13	43	Over 25	30

Examples

The following examples illustrate the application of the table. In these examples the 2-wire system has been used solely for simplicity of illustrations. The same general method of calculation may be applied to other systems of distribution, such as 3, 4 or 5-wire. Conductor sizes according to Table of Order 1306.12.

Example No. 1

A dwelling having an area of 4500 square feet, exclusive of unoccupied cellars, unfinished attics, and open porches.

AREA IN SQUARE FEET, 4500 × 1 watt per sq. ft. = 4500 watts
Allowance for appliances = 1000 watts

COMPUTED LOAD = 5500 watts
DEMAND SELECTED FOR THIS OCCUPANCY, first 2000 square feet—Demand 100 per cent. Excess above 2000 square feet—Demand 60 per cent.
4500 square feet area
2000 square feet at 1 watt per sq. ft. × 1 = 2000 watts
2500 square feet at 1 watt per sq. ft. × 0.6 = 1500 watts
Allowance for appliances = 1000 watts

LOAD AFTER APPLYING DEMAND = 4500 watts
For 110-volt, 2-wire system:
4500 watts ÷ 110 volts = 40.9 amperes.
SIZE OF CONDUCTORS = No. 6 for each wire.
For 220-volt, 2-wire system:
4500 watts ÷ 220 volts = 20.45 amperes.
SIZE OF CONDUCTORS = No. 10 for each wire.
For 110–220-volt, 3-wire system:
4500 watt ÷ 2 × 110 volts = 20.45 amperes.
SIZE OF CONDUCTORS = No. 10 for each wire.
For 120–208 volts, 4-wire, 3-phase system:
4500 ÷ 3 × 120 volts = 12.5 amperes.
SIZE OF CONDUCTORS = No. 14 for each wire.

The above calculation does not take account of ranges or other appliances using more than 1650 watts each.

Example No. 2

Multi-family dwelling having an area of 30,800 square feet with 44 apartments. Meters in the cellar in two banks of 22 each, and individual sub-feeds to each apartment.

AREA IN SQ. FT. per Apt. 700 × 1 watt per sq. ft. = 700 watts
Allowance for appliances 1000 = 1,000

COMPUTED LOAD per Apt. = 1,700 watts
Demand 100 per cent.
1700 ÷ 110 volts = 15.4 amps., therefore for each apt. feeder from meter bank the SIZE OF CONDUCTORS is No. 12 for each of two wires.

SUB-FEEDS

AREA IN SQ. FT. supplied through each meter bank:
22 apts. of 700 sq. ft. each, 15,400—at 1 watt per sq. ft. = 15,400 watts
Allowance for appliances = 22,000 watts

COMPUTED LOAD = 37,400 watts
DEMAND SELECTED for this occupancy:
For first 2000 sq. ft., 100 per cent; 2000 × 1 = 2,000
For load in excess of the first 2000 watts 60 per cent, 35,400 × 0.6 = 21,240

Load after applying Demand = 23,240
23,240 ÷ 110 volts = 211 amperes; therefore, from service to each meter bank, SIZE OF CONDUCTORS, is—No. 4/0 for each wire.

MAINS

AREA IN SQ. FT. 700 × 44 = 30,800 sq. ft. at 1 watt per sq. ft. = 30,800 watts
Allowance for appliances 44 × 1000 = 44,000 watts

COMPUTED LOAD = 74,800 watts
DEMAND SELECTED for this occupancy for first 2000 sq. ft., 100 per cent—2000 × 1 = 2,000 watts
For load in excess of first 2000 watts 50 per cent, 72,800 × 0.5 = 36,400 watts

LOAD AFTER APPLYING DEMAND = 38,400 watts
38,400 ÷ 110 volts = 349; therefore, from the service supply to the cutout where the main is divided into two feeders, one to each meter bank, the SIZE OF CONDUCTORS is 450,000 C.M. each.

The above calculation does not take account of ranges or other appliances using more than 1650 watts each.

e. One common neutral conductor may be employed for three sets of three-wire or two sets of four- or five-wire feeders. If the conductors of such feeders are installed in metal conduit, armored cable, electrical metallic tubing, surface metal raceway, metal underfloor raceway or wireways, all of the conductors, including the common neutral, shall be contained in the same metal inclosure. The size of the neutral and the demand factor applying thereto shall be determined as specified in the previous paragraphs for the maximum unbalanced load to which it may be subject. In addition, the following further demand factor may be applied:

Type of System	Current Load in Outside Conductors After Applying Demand	Further Demand for Neutral Conductors Per Cent
3-wire, D.C. or 1-phase, and 4-wire, 3-phase	0 to 200 amperes	100
3-wire, D.C. or 1-phase, and 4-wire, 3-phase	above 200 amperes	70
5-wire, 2-phase	0 to 200 amperes	140
5-wire, 2-phase	above 200 amperes	100

Order 1320.12. Adequacy Provisions in Residence Occupancies.

a. Where sufficient branch-circuits of appropriate capacities according to conditions as to their subsequent use that are likely to obtain are desired, the following is recommended for all single family dwellings and for all multiple-family dwellings having provisions for cooking (electrically or otherwise) in individual apartments, that have a total floor area for a single family of more than 400 square feet—except dwellings supplied by isolated plants operating at 50 volts or less, as provided in Section 134.0 of this code.

b. In every kitchen, dining room, breakfast room, living room, parlor, library, den, sun room, recreation room and bed room, where any outlet is installed in such room, a sufficient number of receptacle outlets to be installed to provide that no point on the wall, as measured horizontally on the wall, will be more than 15 feet distant from such an outlet. At least one receptacle outlet to be installed near to each permanently installed laundry tub or set of such tubs.

c. In each space intended for the use of a single family, one or more appliance branch circuits to be installed to supply receptacle outlets in the kitchen, pantry, dining room, and breakfast room and adjacent to permanently installed laundry tubs, except that any such outlet may be supplied by an individual appliance branch-circuit. In addition to supplying receptacle outlets, an appliance branch-circuit may also supply one or more permanently connected appliances in these rooms and may also supply an electric refrigerator or other appliance operated by a motor not larger than 6 amperes but no larger motor load shall be supplied by such an appliance branch-circuit.

SECTION 133.0. CRANES AND HOISTS

Order 1330.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, of this Code.

Order 1330.02. Wires.

a. Wires, other than bare collector wires, shall be of approved rubber-covered or of approved slow-burning type.

b. Rubber-covered wire shall not be smaller than No. 12 except on pilot circuits of controllers, where No. 14 may be used.

c. Slow-burning wire shall be used where exposed to severe external heat and between resistances and contact plates unless exposed to moisture when rubber-covered wires shall be used. When rubber-covered wires, so used, are bunched the bunch shall be taped with a flameproof covering.

Order 1330.03. Installation of Wires.

a. Wiring other than bare collector wires and necessary short lengths of open wires at resistors and collectors shall be installed in rigid conduit, or electrical metallic tubing, except that necessary sections of armored cable or flexible metallic conduit may be employed for connection to motors, electric brake, or other features which must be in movable relation to the conduit or tubing system and provided further that in dry places where space is limited, each wire may be separately encased in approved flexible tubing securely fastened in place.

b. Collector wires shall not be used as feeders for any equipment other than the crane or cranes which they are primarily designed to serve.

c. Where wires of crane and hoist circuits leave conduit or other metal raceways they shall be individually bushed, except that for more than four wires they may be bunched, taped with a flameproof covering, and bushed with an insulating bushing. The metal raceway shall terminate as close to the wire terminals as convenience in handling will permit.

d. When a crane or hoist is operated by more than one motor, a common return conductor of proper current carrying capacity is permitted.

Order 1330.04. Collector Wires.

a. When wires are used as 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. Main collector wires carried along runways shall be supported on approved insulating supports placed at intervals not exceeding 20 feet. When run on the same horizontal plane, such wires shall be separated not less than six inches, except for monorail hoists where a spacing of not less than three inches may be used; when run otherwise, the spacing shall be not less than eight inches. Where necessary, intervals between insulating supports may be increased up to 40 feet, the separation between wires being increased proportionately.

These collector wires shall be located in such a position or so guarded that persons working on the crane or persons entering or leaving the crane are reasonably protected against accidental contact.

Exception: Clamp ear hangers will be considered the equivalent of rigid supports.

c. Bridge collector wires shall be kept at least 2½ inches apart and, where the span exceeds 80 feet, insulating saddles shall be placed at intervals not exceeding 50 feet.

It is recommended that the distance between wires be greater than 2½ inches, where practicable.

d. Sizes of collector wire shall conform to the following table:

Distance between rigid supports	Size of wire
0–30 feet	No. 6
31–60 feet	No. 4
over 60 feet	No. 2

e. Conductors along runways and crane bridges may consist of steel tees, angles, tee-rails or other stiff shapes, rigidly carried by approved 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 one

inch. All sections of the conductors shall be mechanically joined to provide a continuous electrical connection.

f. Except in locations to which only qualified persons are admitted it is recommended that collector 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.

g. Remote control collector wires or conductors when carried along runways shall be considered as coming under the classification of Bridge collector wires.

h. Bridge collector wires shall be so arranged or so guarded that hoisting cables cannot be brought into accidental contact with them.

Note: Provision of a light angle iron to prevent the hoisting cables from swinging against the bridge trolley conductors will be considered sufficient protection.

Order 1330.05. Collectors.

a. Collectors shall be so designed as to reduce to a minimum the sparking between them and the collector wire. See also paragraph n of Order 1332.06 of this Code.

Order 1330.06. Switches and Cutouts.

a. The main collector wires shall be protected by a cutout and the circuit shall be controlled by a switch. The switch shall be located within sight of the collector wires and shall be readily operable from the floor or ground.

b. Where cranes are operated from cabs a circuit breaker or switch, capable of interrupting the circuit under heavy loads, and readily controlled by the operator, shall be provided in the leads from the main collector wires unless the current collectors can be safely removed, under heavy loads, from the trolley or third rail.

Exception: Where cabs are attached to the crane trolley an additional main line switch of the same type shall be provided as near as possible to the main collectors.

c. Where more than one motor is employed on a crane, each motor shall have its individual automatic overcurrent protection in accordance with the provisions of Sections 130.8 and 131.0 of this code; provided, however, that where two motors operate a single hoist, carriage, truck or bridge and are controlled as a unit by one controller the pair of motors with their leads may be protected by a single common automatic overcurrent protective device. This cutout shall be located in the cab if there is one.

Exception: Jib cranes, pillar cranes, and floor controlled hoists having a combined motor horse power of 15 or less need not have individual motor protection.

d. On both alternating current and direct current crane protective panels the continuous capacity of the main line switch and main line contactors shall be not less than 50 per cent of the combined short time ratings of the motors nor less than 75 per cent of the short time rating of the largest individual motor.

e. A limit switch shall be provided for the upper limit of travel of crane hoists.

f. Cranes and hoists operated by polyphase alternating current motors shall be protected to prevent starting the motor if,

1. The phase rotation is in the wrong direction, or,
2. There is a failure in any phase.

This protection may be placed ahead of the runway feeders.

Order 1330.07. Controllers.

a. If the crane operates over readily combustible material, the resistances shall be placed in a well ventilated cabinet composed of non-combustible material, so constructed that it will not emit flame or molten metal.

If the resistances are located in a cab, this requirement may be met by constructing the latter of non-combustible material inclosing the sides of the cab from the floor to a point at least 6 inches above the tops of the resistances.

Order 1330.08. Grounding.

a. Motor frames, tracks and entire frame of the crane shall be grounded as prescribed in Section 103 of this Code.

SECTION 133.1. ELEVATORS

(See State Elevator Code for Construction Requirements)

Order 1331.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 131.9 inclusive, of this Code.

b. The maximum voltage permitted on the push buttons of elevator signaling circuits shall be 300 volts to ground.

c. The maximum voltage permitted in the operating devices of electric elevators shall be 300 volts to ground for

automatic control elevators having operating devices in the car and at the landings.

d. No part of any electric circuit having a voltage in excess of 600 volts shall be used on any car control system. Circuits of higher voltage may, however, 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.

Order 1331.02. Wires and Cables.

a. Traveling cables, used as flexible connections between the car and the hoistway, shall satisfy the requirements for Elevator Cable (Types E or ES) in the table of paragraph d of Order 1306.09 of this code.

b. When the length of a traveling cable exceeds 375 feet or when suitable clamps providing adequate support for all conductors are not used, the conductors of traveling cables shall be a composite construction of copper and steel wires or one or more cotton, hemp or rubber-covered-steel strands shall be laid-up with the conductors under their outer covering.

c. No conductor smaller than No. 16 shall be used on the car or in the traveling cable for the elevator operating control or car lighting circuits. Elsewhere, no conductor smaller than No. 14 shall be used for any operating control, power, or car lighting circuits except as otherwise provided for signal and fixture work.

d. No conductor smaller than No. 18 shall be used for any elevator signal circuit or signal traveling cable. When No. 18 conductor is used it shall be protected by fuses not larger than three amperes.

e. Conductors located in the hoistway, except traveling cables and conductors used in signal systems, Classes 1 or 2, (see Section 136.0), shall be installed in rigid conduit except that flexible conduit or armored cable may be used between riser and limit switches, interlocks, push buttons, or similar devices. Conductors and traveling cables, where attached to the car, shall be run in rigid conduit, electrical metallic tubing, or wireways, except that short runs of flexible conduit or armored cable may be used if so located as to be kept free from oil and if securely fastened in place. Split tees and elbows may be used on exposed conduit or tubing work except where the conduit or tubing contains feeders. For operating and control circuits, the number of wires installed in conduit or tubing may be in accordance with Table 3, Order 1305.03.

f. No electric conduits 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. Pipes, conduits and armored cables shall be securely fastened to the hoistway construction.

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.

g. Conduit and electrical metallic tubing shall be equipped with approved terminal fittings having a separate hole for each wire except that for more than four wires the raceway may terminate in an approved single-hole insulating bushing and the wires bunched and taped and painted with an insulating paint. The conduit or tubing shall terminate as close to the wire terminals as convenience in handling will permit, but in no case less than 6 inches from the floor.

h. In auxiliary gutters used in machine rooms under controllers, starters and similar apparatus for elevator machines, the conductor shall be of the rubber-covered type (Type R). The restrictions, given in Section 130.5 of this code as to the number and size of conductors in, and the length of, auxiliary gutters shall not apply.

i. Wires for elevator circuits including operating, control and power wires, and signal wires when an integral part of the wiring system, may be run in the same traveling cable or raceway system when the supply is from the same source of power although the voltage is altered within the system provided that all wires are insulated for the maximum voltage found in the raceway system and the equipment is insulated from ground for this maximum voltage.

j. Where the characteristics of the current are changed within the system by rectifying or converting devices supplied from the elevator feeder circuit, the various classes of conductors referred to in the preceding paragraph, i, shall not be run in the same traveling cable or raceway system, except on the car and at points where it is impracticable to separate them, as at control boards, floor selectors, and hatchway junction boxes.

k. Wires 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.

l. The wires of motor circuits between motors and control panel may be grouped together without any extra insulation of the separate wires, provided the complete group is either taped or corded and painted in a manner to make same a rigid, self-supporting form, not over three feet long, and not in a position liable to mechanical damage or subject to a temperature in excess of 120° F. (49° C.).

m. Wires between main circuit resistors and the back of control panels shall be of the slow-burning (SB) type or of the asbestos-covered type, Type A, as prescribed in Order 1317.01, paragraph h, of this code. All other wiring on control panels unless subjected to a temperature exceeding 120° F. (49° C.) shall be of the rubber-covered type having an outer braid treated with an approved flame and moisture-proof compound or other type especially approved for the purpose and the wires shall be held in such a manner as to be rigid and free from mechanical injury.

n. Wires or groups of wires having flameproof outer cover shall not be used as connections for the operating circuits of elevator controllers unless such outer covering is also moisture-proof.

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.

o. 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, etc., such irregular surfaces shall be made smooth by covering with heavy gauge sheet metal or other suitable means.

p. The wires to the emergency switch, if such a switch is installed, shall be run as a separate cable so grouped with relation to other wires or cables, if there are any, that the fault in these wires or cables will not prevent the emergency switch or stop button from opening the circuit.

q. Every safety switch (so-called baby switch) or other safety stop control conductor cable shall be in a separate unit, not in the same cable with the direction wire.

Order 1331.03. Switches.

a. An externally-operable fused switch disconnecting all wires of the motor circuit or a remote control switch operating a circuit breaker disconnecting all of the wires of the motor circuit, shall be located within sight of the motor, unless permission to locate it elsewhere is given by the authority enforcing this code. Where the elevator is controlled by controlling the field of a generator this requirement shall be interpreted to apply to the switch in the circuit supplying the motor which drives the generator.

(Such switch must comply with Order 1312.02 e)

b. In garages, hatch-limit switches and other spark-emitting devices shall be placed at least four feet above the line of the lowest floor levels unless they are of the vapor-tight type or of the inclosed type with contacts immersed in oil.

c. Each new electric elevator operated by a polyphase alternating-current motor shall be provided with a device which will prevent starting the motor if:

1. The phase rotation is in the wrong direction, or
2. There is a failure in any phase.

d. Every elevator which is provided with an electric brake shall be equipped with shaftway limit switches that will automatically interrupt the power circuit and stop the car at each terminal landing. If the motor of such an elevator is operated by alternating current the limit switches shall be so connected as to automatically stop the elevator in case of phase reversal.

e. Every new elevator controlled by a car switch, and every new freight elevator controlled by hold down push buttons, shall be equipped with two limit switches at each terminal of travel; one of these switches shall be a direction cut-off or equivalent device, and the other a final cut-out switch.

f. The proper functioning of a reverse phase relay hereafter installed shall not be dependent upon the closure of an electric circuit to open the motor circuit in case of failure or reversal of phase.

Note: While protection of existing elevators against phase failure is not required, this hazard should be recognized and removed so far as possible. Even though this requirement is not contained in the code, if there is an outstanding hazard, court ruling is that an owner is responsible for allowing an unsafe condition to exist, the same as though specific orders were in effect.

Order 1331.04. Grounding.

a. For electric elevators, the frames of all motors, elevator machines, controllers, and the metal inclosures for

all electrical devices in or on the car or in the hoistway, shall be grounded.

b. For elevators other than electric, where any electrical conductors are attached to the car, the metal frame of the car, if normally accessible to persons, shall be grounded.

c. Conduit or armored cable attached to elevator cars shall be bonded to grounded metal parts of the car with which they come in contact.

d. Motors, motor-generator sets, elevator machines and controllers mounted on metal beams, which form part of the structural metal frame of a building, shall be deemed to be grounded. Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded when machine is grounded in accordance with this code.

e. Hand operated metallic shifting ropes or cables shall always be grounded.

Order 1331.05. Live Parts.

a. All live parts of electrical apparatus in or on elevator cars or in elevator hoistways shall be suitably inclosed to protect against accidental contact.

b. 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 inclosure or wire grill 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 elevators.

c. When a group of two or more elevator control panels having wiring on the rear, is located in a single machine room, there shall be a clear space of at least thirty-six inches back of the live parts, and not less than eighteen inches on at least one side of the group. There shall also be at least thirty-six inches of clear space in front of the panels. An installation consisting of a single panel shall have at least twenty-four inches clear space in the rear, and other dimensions as above unless otherwise permitted by the authority enforcing this code.

This rule is not intended to forbid mounting controllers on the machine, nor inclosing the rear of control panels in removable cabinets. If such cabinets are installed the prescribed dimensions of clear space apply when the back of the cabinet is removed.

SECTION 133.2. HAZARDOUS LOCATIONS

Order 1332.01. Classification.

a. The provisions of this section are intended to 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. Where the apparatus and wiring are installed in rooms or sections of the building in which the particular hazardous conditions do not prevail, such wiring and apparatus may be of the type approved for such locations. For garages see Section 133.3.

b. Class I locations are those in which flammable volatile liquids, highly flammable gases, mixtures or other highly flammable substances are manufactured, used, handled, or stored in other than their original containers.

This class may include such locations as some parts of dry-cleaning and dry-dyeing plants, pyroxylin plastic manufacturing plants, spray painting establishments, gas plants, varnish manufacturing plants, and establishments or industries involving similar hazardous processes or conditions.

c. Class II locations are those in which (1) combustible dust is thrown, or is likely to be thrown, into suspension in the air in sufficient quantities to produce explosive mixtures or (2) those where it is impracticable to prevent such combustible dust from collecting in such quantities on or in motors, lamps, or other electrical devices that they are likely to become overheated because normal radiation is prevented.

This class may include such locations as some parts of flour mills, feed mills, grain elevators, starch plants, sugar, cocoa and coal pulverizing plants, and establishments or industries involving similar hazardous processes or conditions.

d. Class III locations are those in which easily ignitible fibres or materials producing combustible flyings are handled, manufactured, stored or used, and which are hazardous through such fibres or flyings collecting on or being ignited by arcing contacts, resistors, lamps or similar apparatus. For combustible fibre warehouses see paragraph e of this Order and Order 1332.06 of this Section.

This class may include locations such as some parts of cotton and other textile mills, combustible fibre manufacturing plants and warehouses, cotton gins, clothing manufacturing plants, cotton-seed mills, woodworking plants, and establishments or industries involving similar hazardous processes or conditions.

e. Class IV locations are those in which easily ignitible combustible fibres are stored or handled (except in rooms where in process of manufacture) and which are hazardous through such fibres being ignited by arcing contacts, resistors, lamps, or similar apparatus.

This class may include locations such as warehouses in which are stored or handled combustible fibres such as cotton (including cotton linters and cotton waste), sisal or henequen, ixtle, jute, hemp, tow, cocoa fibre, oakum, baled waste, kapok, Spanish moss, excelsior, and other similarly readily ignitible fibres.

Order 1332.02. General.

a. The requirements of this section shall be considered additional or amendatory to those prescribed in Sections 130.1–132.0 inclusive, of this Code.

Order 1332.03. Class I Locations.

a. In locations judged to be as described for Class I in paragraph b of Order 1332.01 the following provisions shall be observed.

b. No service entrance equipment, switchboards or panelboards shall be installed unless of a type approved for use in explosive atmospheres.

c. Rigid conduit with explosion-proof joints and fittings shall be employed as the type of wiring. Where it is necessary to employ flexible connections, as at motor terminals, an approved flexible fitting of the explosion-proof type may be used. At points where conduit terminates in an inclosure in which arcing or sparking is likely to occur, such as at motor terminals, switch boxes, and the like, and wherever a conduit leads from a hazardous to a non-hazardous location, the conduit shall be sealed off by a sealing compound approved for the purpose which is not affected by the surrounding atmosphere or liquids, and which has a melting point of not less than 200° F. The sealing compound shall have a thickness of not less than 5/8 inch.

Joints in approved rigid conduit made with approved threaded couplings having five full threads engaged are recognized as being explosion-proof.

d. Fuses shall not be installed unless mounted within explosion-proof inclosures. The fuse cutout bases and their inclosures shall be approved as unit devices for use in explosive atmospheres. Circuit-breakers, if used, shall be of a type approved for use in explosive atmospheres.

e. Motors shall be of types approved for use in explosive atmospheres.

f. Motor controllers, thermal cutouts, switches, relays, the switches and contactors of auto-transformer starters, resistance or impedance devices or other devices or apparatus, which in their normal operation tend to create arcs, sparks, or high temperatures, shall not be installed unless such devices or apparatus are of types approved for use in explosive atmospheres.

It is recommended that motor controllers be of the remote control type with the main contactors located at a point where the hazardous conditions of this class do not prevail, auxiliary control push buttons or switches of a type approved for use in explosive atmospheres may then be placed in the most convenient locations.

g. Electric heating appliances shall not be used unless they are of a type approved for the particular location or type of material in or with which they are used.

h. Switches controlling lamps shall not be installed unless of a type approved for use in explosive atmospheres.

i. Lamps in fixed positions shall be inclosed in a manner approved for explosive atmospheres and where exposed to breakage shall be properly protected by substantial metal guards or other approved means. Lamps shall not be of the pendant type unless supported rigidly by conduit hangers. Where rubber covered wire is used it shall have insulation not less than 3/64 inch thick.

j. No motor, lamps or lighting fixtures of any type shall be located within spray booths, in ventilating ducts connected therewith nor in any location where there is a possibility of the spray lodging upon them.

Motors in spray-painting establishments that are located outside of paint-spray booths and ventilating ducts and are judged by the authority enforcing this code to be outside of the hazardous area may be of any standard totally-inclosed type or of the open induction type having no brushes, make-and-break contacts, collectors, or other arcing or sparking parts.

k. The auxiliaries of mercury-vapor lamps shall be offset at least ten feet from spray booth working faces.

l. Sufficient general illumination shall be provided by fixed lighting units to eliminate, so far as possible, the need for portable lamps. When portable lamps are necessary, they shall be inclosed in a manner approved for explosive atmospheres and shall be properly protected by substantial metal or other approved types of guards to prevent breakage. Sockets for portable lamps shall be of the keyless moulded composition type with no exposed metal parts.

m. When necessary to use portable lamps, or other portable current consuming devices, approved flexible cord designed for hard usage such as Type S or Type PA shall be used. Such a flexible cord shall contain one extra insulated conductor which shall be properly connected to form a grounding connection for metal lamp guards, motor frames, and all other exposed metal portions of such portable lamps and devices.

n. Connections of portable cords direct to supply conductors shall first be made mechanically secure and shall then be soldered and heavily taped. In addition the cord shall be securely supported so that the probability of a break in the conductors at this point will be minimized.

o. Receptacles and attachment plugs, if used, shall be so connected as a part of a unit device with an explosion proof interlocking switch that the plug cannot be removed while the switch is in the "on" position, or approved devices which seal the arc, made when current is interrupted, by means of an explosion-proof or a vapor-proof inclosure shall be used. Such receptacles and plugs shall be of the polarized type providing a connection for the grounding wire of the portable cord.

p. The exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable appliances, fixtures, cabinets, cases, and conduit shall be grounded as provided in Section 103 of this Code. The locknut-bushing and the double-lock-nut type of contact shall not be depended upon for bonding purposes, bonding jumpers with proper fittings or other approved means being required to assure an effective grounding circuit.

q. There shall be no exposed live parts.

Order 1332.04. Class II Locations.

a. In locations judged to be as described for Class II locations in paragraph c of Order 1332.01 the following provisions shall be observed:

b. Service entrance equipment, and all panelboards and switchboards should not be placed in locations of this class, but, if impracticable to locate elsewhere, all live parts shall be inclosed in dust-tight metal cases or cabinets having provision for external operation only, or shall be located in a separate dust-tight room built of or lined with substantial non-combustible materials and having a self-closing door, so constructed and installed as to adequately exclude dust.

c. Fuses shall not be placed in locations described in this class unless inclosed in dust-tight metal cabinets or cases. Circuit-breakers shall be of the dust-tight or dust-tight oil-immersed type.

d. Rigid conduit shall be the wiring method employed. Where it is necessary to employ flexible connections, as at motor terminals, a short length of flexible steel conduit may be used.

e. Where explosive dusty atmospheres are likely to be present, as in (1) of paragraph c of Order 1332.01, motors or generators having brushes or sliding contacts shall have such brushes or sliding contacts inclosed in substantial dust-tight housings or shall be of the totally inclosed, inclosed-fan-ventilated, or inclosed-pipe-ventilated types or shall be inclosed in separate dust-tight rooms or housings built of or lined with substantial non-combustible materials and so constructed as to adequately exclude dust and properly ventilated from a source of clean air.

It is recommended that all motors installed in dusty locations be of the totally inclosed, inclosed-fan-ventilated, or inclosed-pipe-ventilated types.

f. Where it is impracticable to prevent combustible dust from collecting in dangerous quantities on or in motors as in (2) of paragraph c of Order 1332.01, all motors shall be of the totally-inclosed, inclosed-fan-ventilated, or inclosed pipe-ventilated types, or shall be inclosed in separate dust-tight rooms or housings built of or lined with substantial non-combustible materials and so constructed as to adequately exclude dust and properly ventilated from a source of clean air.

The above conditions often exist in sugar, cocoa and coal pulverizing rooms, cupolas, head-houses, basements and other points in grain elevators, flour-mills and feed-mills where grains are spouted, and in similar locations. Where the installation and maintenance are such that the hazardous conditions do not exist, the foregoing requirements are not called for and are waived.

g. When motors of the inclosed pipe-ventilating type are used, or when motors are inclosed in rooms or housings, the vent pipes shall extend to the outside of the building to a source of clean air. The vent pipes shall be of metal, substantially constructed and with each section attached to the next by riveting, welding, or other approved methods. When motors are intended to be moved on their bases, a slip or universal joint tight enough to prevent the entrance

of dust shall be provided in the vent pipes. The outer ends of vent pipes shall be suitably screened to prevent the entrance of animals or birds.

h. Motor controllers, thermal cutouts, switches, relays, the switches and contactors of auto-transformer starters, resistance or impedance devices, or other devices or apparatus, which in their normal operation tend to create arcs, sparks, or high temperatures, shall not be installed in these locations unless such devices or apparatus are inclosed in dust-tight cases or cabinets or are of the dust-tight or dust-tight oil-immersed type, and so designed that the device may be operated without opening the cabinet or case.

It is recommended that motor control devices be of the remote control type with the main contactors located in separate rooms or compartments built of non-combustible materials so constructed as to exclude dust. The remote control push buttons or switches of the oil-immersed or dust-tight type may then be placed in the most convenient locations.

i. Electric heating appliances shall not be used unless of a type approved for installation in dusty atmospheres.

j. Lamps in fixed positions shall be inclosed in approved dust-tight globes, and where exposed to mechanical injury, shall be protected by substantial guards. Heavy fixtures used as pendants shall be supported by conduit hangers or chains to prevent strain on the wires. Where rubber covered wire is used it shall have insulation not less than 3/64 inch thick. Sockets and receptacles shall be of the keyless type, and unless individual switches are provided, shall be located at least 7½ feet above the floor, or shall be otherwise so located or guarded that the lamps cannot readily be backed out by hand.

When light is required for the interior of bins, hoppers, elevators, conveyors and similar equipment or construction, it is recommended that such light shall, whenever practicable, be supplied by means of lamps, inclosed in dust-tight globes properly protected against mechanical injury, and mounted flush in the walls or floors of the equipment or construction. No wiring or fixtures should be permitted inside of bins, hoppers, elevators or conveyors.

k. Sufficient general illumination shall be provided by fixed lighting units to eliminate so far as possible the need for portable lamps. When portable lamps are necessary, they shall be inclosed in dust-tight globes properly protected by substantial metal or other approved types of guards to prevent breakage. Sockets for portable lamps shall be of the moulded composition or metal-jacketed porcelain, keyless type.

l. When necessary to use portable lamps, or other portable current consuming devices, approved flexible cord designed for hard usage such as Type S or Type PA shall be used. Such a flexible cord shall contain one extra insulated conductor which shall be properly connected to form a grounding connection for metal lamp guards, motor frames, and all other exposed metal portions of such portable lamps and devices.

m. Receptacles and attachment plugs, if used, shall be so connected, as a part of a unit device with a dust-tight interlocking switch that the plug cannot be removed while the switch is in the "on" position or approved devices which seal the arc, made when current is interrupted, by means of dust-tight inclosure shall be used. Such receptacles and plugs shall be of the polarized type providing a connection for the grounding wire of the portable cord.

n. Connections of portable cords direct to supply conductors shall first be made mechanically secure and shall then be soldered and heavily taped. In addition, the cord shall be securely supported so that the probability of a break in the conductors at this point will be minimized.

o. The exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable appliances, lighting fixtures, cabinets, cases, and conduit, shall be grounded as provided in Section 103 of this code. The locknut-bushing and double-locknut type of contact shall not be depended upon for bonding purposes, bonding jumpers with proper fittings or other approved means being required to assure an effective grounding circuit.

p. There shall be no exposed live parts.

Order 1332.05. Class III Locations.

a. In locations judged to be as described for Class III locations in paragraph d of Order 1332.01 the following provisions shall be observed:

b. Service entrance equipment and all switchboards and panelboards should not be placed in locations of this class, but, if impracticable to locate them elsewhere, all live parts shall be inclosed in dust-tight metal cases or cabinets with provision for external operation only, or shall be located in separate dust-tight rooms built of or lined with substantial non-combustible materials and with self-closing doors, so constructed and installed as to adequately exclude flyings or lint.

c. All fuses shall be inclosed in dust-tight metal cases or cabinets. Circuit-breakers shall be of the dust-tight oil-immersed type, or shall be inclosed in dust-tight metal cases.

d. Rigid conduit shall be the wiring method employed. Where it is necessary to employ flexible connections, as at motor terminals, a short length of flexible steel conduit may be used.

e. Where it is impracticable to prevent lint and flyings from collecting in dangerous quantities on or in motors, as in cotton gins or the seed-cleaning and linter rooms of cotton seed oil mills, all motors shall be of the totally-inclosed, totally-inclosed fan-cooled or totally inclosed-pipe-ventilated types, or shall be inclosed in separate dust-tight rooms or housings built of or lined with substantial, non-combustible material so constructed as to adequately exclude lint or flyings and be properly ventilated from a source of clean air. Elsewhere if motors or generators having brushing or sliding contacts are used they shall:

1. Be of the totally-inclosed, totally-inclosed fan-cooled, or inclosed-pipe-ventilated types, or

2. Be inclosed in separate rooms or housings as specified above, or

3. Have brushes or sliding contacts inclosed in substantial tight metal housings.

f. When motors of the inclosed pipe-ventilating type are used, or when motors are inclosed in rooms or housings, the vent pipes shall extend to the outside of the building to a source of clean air. The vent pipes shall be of metal, substantially constructed and with each section attached to the next by riveting, welding, or other approved methods. When motors are intended to be moved on their bases, a slip or universal joint tight enough to prevent the entrance of dust shall be provided in the vent pipes. The outer ends of vent pipes shall be suitably screened to prevent the entrance of animals or birds.

g. Motor controllers, thermal cutouts, switches, relays, the switches and contactors of auto-transformer starters, or other devices or apparatus which in their normal operation tend to create arcs or sparks shall not be installed unless such devices or apparatus are inclosed in dust-tight metal cases or cabinets, or are of the dust-tight oil-immersed type, and are so designed that they may be operated without opening the cabinet or case.

h. Rheostats, resistance boxes, or other resistance devices, shall be inclosed in non-combustible cases, so constructed as to adequately exclude flyings or lint.

i. Electric heating appliances shall not be used unless of a type approved for installation in locations where combustible flyings or lint are present.

j. Where there is a possibility of flyings or lint collecting about lamps in fixed positions, such lamps shall be inclosed in globes of dust-tight type, and when exposed to mechanical injury, shall be protected by substantial metal or other approved types of guards to prevent breakage. Heavy fixtures, used as pendants, shall be supported by conduit hangers or chains to prevent strain on the wires. Where rubber covered wire is used it shall have insulation not less than 3/64 inch thick. Socket and receptacles shall be of the keyless type and, unless individual switches are provided, shall be located at least 7½ feet above the floor, or shall be otherwise so located or guarded that the lamps cannot readily be backed out by hand.

k. Sufficient general illumination shall be provided by fixed lighting units to eliminate, so far as possible, the need for portable lamps. When portable lamps are necessary, they shall be inclosed in dust-tight globes properly protected by substantial metal or other approved types of guards to prevent breakage. Sockets for portable lamps shall be of the non-combustible, non-absorptive moulded composition type with no exposed metal parts, and shall be of the keyless type.

l. When necessary to use portable lamps, or other portable current consuming devices, approved flexible cord designed for hard usage such as Type S or Type PA shall be used. Such a flexible cord shall contain one extra conductor, which shall be properly connected to form a grounding connection for metal lamp guards, motor frames, and all other exposed metal portions of such portable lamps and devices.

m. Receptacles and attachment plugs, if used, shall be of approved type which seal the arc, made when current is interrupted, by means of a dust-tight inclosure. Such receptacles and plugs shall be of the polarized type providing a connection for the grounding wire of the portable cord.

It is recommended that attachment plugs and receptacles be so connected, as a part of a unit device with a dust-tight interlocking switch, that the plug cannot be inserted or removed while the switch is in the "on" position.

n. Connections of portable cords direct to supply conductors shall first be made mechanically secure and shall then be soldered and heavily taped. In addition, the cord shall be securely supported so that the probability of a break in the conductors at this point will be minimized.

o. The exposed noncurrent-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable appliances, lighting fixtures, cabinets, cases, and conduit shall be grounded as provided in Section 103 of this Code. The lock-nut-bushing and double-lock-nut type of contact shall not be depended upon for bonding purposes, bonding jumpers with proper fittings or other approved means being required to assure an effective grounding circuit.

Order 1332.06. Class IV Locations.

a. In locations judged to be as described for Class IV locations in paragraph e of Order 1332.01, the following provisions shall be observed:

b. Service entrance equipment and all switchboards and panelboards shall not be placed in locations of this class, but, if impracticable to locate them elsewhere, all live parts shall be inclosed in dust-tight metal cases or cabinets with provision for external operation only, or shall be located in separate dust-tight rooms built of or lined with substantial non-combustible materials and with self-closing doors, so constructed and installed as to adequately exclude flyings or lint.

c. Fuses and circuit breakers shall preferably not be installed in storage rooms, but if impracticable to locate them elsewhere, all live parts shall be inclosed in dust-tight metal cases or cabinets or shall be located in separate dust-tight rooms built in accordance with the provisions of paragraph b of this order.

d. Rigid conduit shall be the wiring method employed. Where it is necessary to employ flexible connections, as at motor terminals, a short length of flexible steel conduit may be used.

It is recommended that pilot lights be installed on the outside of storage rooms to indicate when the current in the rooms is "on" or "off."

e. Motors and generators shall be of the totally-inclosed, totally inclosed-fan-cooled, or inclosed-pipe ventilated type, or shall be inclosed in separate dust-tight rooms or housings built of or lined with substantial non-combustible materials and so constructed as to adequately exclude flyings or lint and properly ventilated from a source of clean air.

f. When motors of the inclosed-pipe-ventilated type are used, or when motors are inclosed in rooms or housings, the vent pipes shall extend to the outside of the building to a source of clean air. The vent pipes shall be of metal, substantially constructed and with each section attached to the next by riveting, welding, or other approved methods. When motors are intended to be moved on their bases, a slip or universal joint tight enough to prevent the entrance of dust shall be provided in the vent pipes. The outer ends of vent pipes shall be suitably screened to prevent the entrance of animals or birds.

g. Resistance devices unless installed in rooms such as described in paragraph b of this order shall be inclosed in especially approved metal cases of dust-tight design. These shall be so constructed that ignition of lint or flyings by direct contact with the inclosing case, whether in normal operation or in case of accident, is avoided.

h. Motor controllers, thermal cutouts, switches, relays, switches and contactors of auto-transformer starters, impedance devices, or other devices or apparatus used in connection with the control of power or other circuits shall not be installed in these locations unless such devices or apparatus are inclosed in dust-tight cases or cabinets and so designed that the device may be operated without opening the cabinet or case.

It is recommended that motor control devices be of the remote control type with the main contactors located in separate rooms or compartments built of or lined with substantial non-combustible materials are so constructed as to exclude flyings or lint. The remote control push buttons or switches of the oil-immersed or dust-tight type may then be placed in the most convenient locations.

i. Electric heating appliances shall not be used unless of a type approved for installation in locations where combustible flyings or lint are present.

j. Sufficient general illumination shall be provided by fixed lighting units to eliminate so far as possible the need for portable lamps. Lamps shall not be installed where they are likely to be injured when bales are being tiered or handled. Lighting fixtures shall be wired with not less than No. 14 wire and the fixture wiring shall be inclosed in rigid conduit or the equivalent in thickness. Lamps may be in receptacles attached directly to the outlet box covers. Lamps and their sockets shall be so inclosed that in the

event of a burn out of the lamp or socket no spark or hot metal can escape from the inclosure.

k. When portable lamps are necessary, they shall be inclosed in dust-tight globes properly protected by substantial metal or other approved types of guards to prevent breakage. Sockets for portable lamps shall be of the moulded composition or metal-jacketed porcelain, keyless type.

l. When necessary to use portable lamps, or other portable current-consuming devices, approved flexible cord designed for hard usage such as Type S or Type PA shall be used. Such a flexible cord shall contain one extra insulated conductor which shall be properly connected to form a grounding connection for metal lamp guards, motor frames, and all other exposed metal portions of such portable lamps and devices.

m. Receptacles and attachment plugs, if used, shall be of approved type which seal the arc, made when current is interrupted, by means of a dust-tight inclosure. Such receptacles and plugs shall be of the polarized type providing a connection for the grounding wire of the portable cord.

It is recommended that attachment plugs and receptacles be so connected, as a part of a unit device with a dust-tight interlocking switch, that the plug cannot be inserted or removed while the switch is in the "on" position.

n. Electric cranes operating over combustible fibres shall not be operated on a system with a grounded conductor. Feeders for electric cranes shall be provided 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 fibres shall be protected by suitable 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 Type S or PA portable conductors equipped with approved type of reel or take-up device.

o. Storage battery charging equipment shall be of approved type located in separate rooms built of or lined with substantial non-combustible materials so constructed as to adequately exclude flyings or lint, and shall be well ventilated. Electric trucks shall be charged only in such rooms.

p. The exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable appliances, lighting fixtures, cabinets, cases, and conduit, shall be grounded as provided in Section 103 of this code. The locknut-bushing and double-locknut type of contact shall not be depended upon for bonding purposes, bonding jumpers with proper fittings or other approved means being required to assure an effective grounding circuit. The wheels of electric trucks shall be provided with rubber tires or made of non-conducting material.

SECTION 133.3. GARAGES

Order 1333.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, of this Code.

b. A garage shall be deemed to be 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 demonstration 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.

(See State Building Code)

Order 1333.02. Wiring.

a. Where floor area is sufficient to permit the storage of more than two vehicles, the building must meet the building code requirements for a public garage, either conduit work, surface metal raceways, armored cable or electrical metallic tubing, as specified in Orders 1305.03, 1305.04, 1305.05 and 1305.08 respectively of Section 130.5, shall be employed as the wiring method. Where the floor space will accommodate not more than two vehicles, any approved wiring method may be employed.

b. Cutouts, switches, attachment plug receptacles and fixed lamp-holding devices, unless of a type approved for use in Class I Locations as defined in Section 133.2, shall be located at least four feet above the floor, except in a showroom separated by a partition from the garage proper.

c. Approved reinforced cord shall be used for pendent lamps.

Order 1333.03. Portables.

a. Approved portable cord designed for rough usage, such as hard-service cord, stage cable or packinghouse cord, shall be used to connect portable lamps, motors or other appliances. The portable cord shall carry the male end of an approved 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.

b. Portable electric hand lamps shall be equipped with keyless sockets of non-combustible, non-absorbent insulating material, large handles of non-absorbent insulating material (such as impregnated wood), basket guards, reflectors and proper cords.

Order 1333.04. Charging Cables.

a. Approved Type S cord shall be used for charging purposes.

b. Connectors shall be of approved type and of at least 50 amperes capacity, and shall be so designed or so hung that at least one will break apart readily at any position of the charging cable. Live parts shall be guarded from accidental contact. The fixed, or wall, connector shall be kept at least 4 feet above the floor, and, if not located on a switchboard or charging panel, shall be guarded from accidental contact. Where plugs for direct connection to vehicles are suspended from overhead wiring they shall hang at least 6 inches above the floor and no connector need be placed in the cable or at the outlet.

Order 1333.05. Switchboards and Charging Panels.

a. Switchboards and charging panels carrying spark-producing devices not located at least four feet above the floor and which are not of types approved for use in Class I Locations as defined in Section 133.2, shall be located in a room or inclosure provided for the purpose.

Order 1333.06. Generators, Motors and Control Apparatus.

a. Generators, motors and control apparatus, that embody the use of commutators, collector rings or other make-and-break or sliding contacts shall either be of the totally-inclosed type or be located at least four feet above floor.

b. Generators, motors, control apparatus and the like, having commutators, collector rings, or other make-and-break or sliding contacts located more than four feet above floor shall, unless of the totally-inclosed type, have wire screens or perforated metal placed at commutator or brush ends to prevent the falling of particles. 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 1333.07. Special Precautions.

a. Live parts of all devices shall be guarded to prevent accidental contact by foreign bodies.

Order 1333.08. Grounding.

a. Conduit, metal sheaths, raceways and exposed metal frames and inclosures of equipments and the like shall be grounded when and in the manner prescribed in Section 103 of this Code. This shall apply to all devices except pendent and portable lamps operating on grounded systems of not more than 150 volts to ground.

Order 1333.09. Flexible Cords.

a. Flexible cords used to supply pendent or portable lamps or portables which include lamp-holding devices on polarized wiring systems, shall have one conductor identified, and such identified conductor shall be connected to the screw shell of the lamp-holding device. Receptacles, attachment plugs, connectors, and similar devices used with such cord shall be of the polarity type.

SECTION 133.4. MOTION-PICTURE STUDIOS

Note: The regulations with regard to the installation of sound reproduction equipment found in Section 133.4 shall apply in theaters.

Order 1334.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, of this code, but shall not be applied where only approved slow-burning (cellulose acetate or equivalent) film is used.

b. A motion-picture exchange, factory, laboratory or studio shall be deemed to be that building or portion of a building in which motion-picture films are manufactured, exposed, developed, printed, rewound, repaired, stored, etc.

Order 1334.02. Wiring.

a. Rigid conduit or other types of metal inclosures recognized in Section 130.5 of this code shall be the wiring method employed, except as follows:

1. Approved portable cables and flexible cords may be used on studio stages and at other locations where the other wiring methods are impracticable.

2. The authority enforcing this code may permit two 2-conductor lead-covered cables in ¾ inch conduit providing the cross-sectional area of each such cable does not exceed .11 square inches.

3. The authority enforcing this code may permit two 2-conductor No. 19 lead-covered cables in ½ inch conduit, providing 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.

b. Side wall lamp outlets shall consist of receptacles inclosed in approved outlet boxes equipped with open-end guards riveted to the covers of the boxes.

c. Pendent lamps shall be suspended by means of approved reinforced cords, armored cord or armored cable and shall be protected by substantial wire guards.

d. Each portable lamp shall be composed of approved hard service flexible cord, approved composition or approved metal-sheathed, porcelain keyless socket, handle, hook and substantial guard. The cord shall carry the male end of an approved 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 cord. The connector shall be kept at least 1 foot above the floor.

e. At patching tables, approved composition or metal-sheathed porcelain keyless sockets shall be employed and shall be equipped with suitable means to guard lamps from mechanical injury.

f. In film-storage vaults lamps shall be installed on rigid fixtures and inclosed in vaporproof globes. Such lamps shall be controlled by a double-pole-switch, located outside the vault. Electric motors or portable lamps shall not be placed in the vault.

g. All live parts shall be inclosed to prevent accidental contact by persons and objects. All switches shall be of the externally operable type. Rheostats shall be placed in cabinets which inclose all live parts, having only the operating handles exposed.

h. If motors or generators having brushes or sliding contacts are used they shall:

1. Be of the totally-inclosed, inclosed-fan-cooled, or inclosed-pipe-ventilated types, or

2. Be inclosed in separate rooms or housings built of noncombustible materials, so constructed as to adequately exclude flyings or lint, and properly ventilated from a source of clean air, or

3. Have brush or sliding contact end of motor inclosed by solid metal covers, or

4. Have brushes or sliding contacts inclosed in substantial, tight, metal housings, or

5. Have the upper half of brush or sliding contact end of the motor inclosed by a wire screen or perforated metal and the lower half inclosed by solid metal covers, or

6. Shall 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.

7. The provisions of the foregoing sub-paragraphs, 1 to 5 inclusive, 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 inclosed in conformity with the provisions of paragraph g of this order.

i. All conduit, armored cable or metal raceways, exposed metal frames, and inclosures or equipment shall be grounded as prescribed in Section 103 of this Code. This shall apply to all devices, except pendent and portable lamps operating at not more than 150 volts to ground.

Order 1334.03. Sound Recording and Reproduction.

a. Automatic overcurrent protective devices shall be provided on branch circuits to supply A voltage according to the provisions of Section 130.8 of this code. Branch circuits to supply B voltage shall have automatic overcurrent protection rated not over one ampere. Branch circuits to supply C voltage may be without automatic overcurrent protection.

b. Wires of different systems shall not be grouped either in conduit or other metallic inclosures or in portable cords and cables, except under the following conditions:

1. All conductors so grouped shall have insulation of a thickness not less than is required elsewhere in this code for the maximum voltage applied to any wire of the group and in any case for not less than 600 volts.

2. Portable cords and cables shall be specifically approved for use with sound recording and reproducing equipment.

In view of the technical features affecting the practical operation of sound recording and reproduction circuits, it is recommended that

sound engineers designing or supervising installations consult with the interested authority enforcing this code relative to the character and type of such circuits to be installed in conduits or other metallic inclosures.

c. Input leads to a motor-generator or to a rotary converter shall be run separately from the wires supplied therefrom.

d. Storage batteries shall be installed in accordance with requirements of Section 131.8 of this code.

e. Insulation of wires exposed to oil or oil-drippings shall be of a type approved for interior wiring and that will not be injured by oil or shall be protected from such injury by a seamless metallic covering over the insulation. This protection need not be provided for motor leads so located on the motor frame as to be exposed only to occasional excess oil from motor bearings.

f. The number of wires in conduits and electrical metallic tubing shall be limited according to Table 3 of paragraph q of Order 1305.03 of this code. The number of wires in wireways and auxiliary gutters shall be such that not more than 75 per cent of the depth of the wireways or auxiliary gutters shall be occupied by the wires.

g. Wires, the outer braids of which are not treated with an approved flame-retarding compound and which terminate in groups on patch-panels or similar connection boards, shall be covered with a single wrapping of asbestos tape or equivalent material over convenient groups, except where a metallic covering is carried to within six inches of the terminals.

h. Metal-trough raceways may be installed in concealed spaces 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 up of sections shall contain a ground conductor to which each section shall be bonded and grounded as prescribed by Section 103 of this code.

i. The thickness of metal for trough raceways shall be as specified for auxiliary gutters, see Order 1307.03 of Section 130.7 of this code. Metal trough-raceways shall have ample strength and rigidity so they may keep their shape. Seams and corners, back edges and splices in sheet metal, shall be flanged or lapped over unless made of continuous weld or they may be butt-jointed if reinforced by flat iron strips of metal of at least the same thickness as that of the

raceway. Seams shall not show open cracks when finished and before the raceway or ducts are painted or enameled. Covers shall be of at least the same thickness of metal as the raceway and secured to it by machine screws spaced not more than one foot apart. If the raceway is placed in a floor with its cover flush with the flooring, its covers shall be of at least ¼ inch steel, provided that when such a raceway is located in the rear of patch, or other equipment, panels or other locations where protection from the moving of heavy objects would be unnecessary, the thickness of the cover of such raceway may be not less than 0.140 inch, No. 10 U. S. Standard sheet metal gauge.

SECTION 133.5. MOTION-PICTURE PROJECTORS AND EQUIPMENT

Order 1335.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 131.9, inclusive, of this Code.

b. The so-called professional types of projectors, such as are commonly used in theatres and motion pictures houses, shall be located in fireproof booths.

The professional projector employs a film which is 1⅜ inches wide and has on each edge 5.4 perforations per inch.

c. 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.

d. All live parts shall be inclosed or otherwise guarded to prevent accidental contact of persons or objects.

e. All conduit, armored cable, metal raceways, exposed metal frames and inclosures of equipment shall be grounded as prescribed in Section 103 of this Code. This shall apply to all devices except pendent and portable lamps operating at not more than 150 volts to ground.

Order 1335.02. Projectors of Professional Type.

a. Projectors of the professional type including the lamp house for arc or incandescent lamps therefore shall be expressly designed and approved for this purpose. Arc or incandescent lamp inclosures shall be marked with the name or trade mark of the maker and with the current and voltage rating for which they are designed.

b. Wires shall be of sufficient carrying capacity for the current rating of the projector used, but in no case shall

wires smaller than No. 10 be employed to supply the projector outlet.

c. Rheostats, transforming devices and any substitute therefor, shall be of types expressly designed and approved for the purpose. They shall be judged as component parts of the projector equipment as to installation and location.

d. Top and bottom magazines shall be so designed in some approved manner as to prevent the entrance of flame. No solder shall be used in their construction. The front side of each magazine shall consist of a door swinging horizontally and equipped with a substantial latch.

e. An automatic shutter shall be provided and permanently attached to the gate frame. The construction of the shutter shall be such as to shield the film from the beam of light whenever the film is not running at operating speed.

f. Motor-driven projectors shall be of a type expressly designed and approved for such operation. Such projectors shall be used only by permission of the authority enforcing this code, and when the projector is in charge of a qualified operator.

g. Switches if used shall be of externally operable type.

Order 1335.03. Inclosure for Projectors of Professional Type.

(See State Building Code)

a. The inclosure shall be constructed and equipped in accordance with the requirements of the Wisconsin State Building Code and shall be provided with proper lights.

Note: This lighting should be supplied from the emergency circuit which shall not be located inside of the booth.

Order 1335.04. Wiring, Etc., in Projection Rooms and Booths.

a. Rigid conduit or other types of metal inclosures recognized in Section 130.5 of this code shall be the wiring method employed, except as follows:

1. Approved portable cables and flexible cords may be used on studio stages and at other locations where the other wiring methods are impracticable.

2. The authority enforcing this code may permit two 2-conductor lead-covered cables in ¾-inch conduit providing the cross-sectional area of each such cable does not exceed .11 square inch.

3. The authority enforcing this code may permit two 2-conductor No. 19 lead-covered cables in one-half-inch conduit, providing 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.

b. Approved asbestos-covered wire (Type A) shall be used on all arc lamps or other equipment when the ambient temperature at the wire as installed will exceed 120° F. (or 49° C.).

c. Approved hard service cord, types K, S or SJ, shall be used where necessary on all portable equipment.

d. Each incandescent lamp not otherwise protected by non-combustible shades or other inclosures shall be provided with an approved lamp guard.

e. Wires of different systems shall not be grouped either in conduit or other metallic inclosures or in portable cords and cables, except under the following conditions:

1. All conductors so grouped shall have insulation of a thickness not less than is required elsewhere in this code for the maximum voltage applied to any wire of the group and in any case for not less than 600 volts.

2. Portable cords and cables shall be specifically approved for use with sound recording and reproducing equipment.

In view of the technical features affecting the practical operation of sound recording and reproduction circuits, it is recommended that sound engineers designing or supervising installations consult with the interested authority enforcing this code relative to the character and type of such circuits to be installed in conduits or other metallic inclosures.

f. A motor-generator installed in the projector enclosure shall have the commutator end or ends suitably protected from mechanical injury by wire screens or other suitable means. The measures, described in either of the sub-paragraph 1–6 inclusive of paragraph h of Order 1334.02 shall be considered as providing the required protection.

g. Rheostats, transformers, rectifiers, motor-generators or similar equipment used to control or supply current to arc lamps on projectors shall preferably be installed in a separate room from the inclosure for projectors. When placed in such projector inclosure, however, they shall be so located and/or guarded that no arcing from any cause such as grounds, short circuits or from brushes on commutators may ignite any exposed film.

Order 1335.05. Projectors of Non-Professional Type.

(See State Building Code)

a. Motion-picture projecting machines not intended for installation and use in permanent and ventilated booths

shall be permitted only for projecting film of an approved slow-burning (cellulose acetate or equivalent) type.

b. All such equipment shall be expressly approved, including current-controlling devices and other essential operating parts.

c. The source of illumination of the projected view shall be an approved lamp of a pattern expressly intended for stereopticon use or for motion-picture projection.

d. 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.

e. Machines shall be marked with the name or trade-mark of the maker, and with the voltage and current rating for which they are designed, and shall also be plainly marked, "For use with slow-burning films only."

SECTION 133.6. THEATERS AND ASSEMBLY HALLS; INCLUDING MOTION-PICTURE HOUSES

(See also State Building Code)

Order 1336.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, of this Code.

b. A theater shall be deemed to be that building, or part of a building, regularly or frequently used for dramatic, operatic, motion picture or other performances or shows, or which has a stage for such performances used with scenery or other stage appliances.

See State Building Code for definitions and construction rules.

c. Emergency illumination shall be installed in accordance with Section 134.1 of this code.

Note: See State Building Code for required lights.

Order 1336.02. Auditorium.

a. Approved conduit, electrical metallic tubing, surface metal raceways or armored cable shall be employed as the wiring method.

b. Receptacles shall be inclosed in boxes.

c. Not more than one set of fuses shall be interposed between service fuses and exit lights.

d. Emergency lights shall not be connected to or controlled by the stage lighting control, but from the lobby or other convenient place in the front of the theater.

e. All fuses shall be inclosed in approved cabinets.

Order 1336.03. Stage.

a. Approved conduit, electrical metallic tubing, surface metal raceways or armored cable shall be employed as the wiring method.

b. The switchboard shall be of the dead-front type, and shall carry a metal hood running the full length of the board and protecting the latter from falling objects. Switchboards having current-carrying parts exposed on back shall be elevated or guarded by suitable railings to prevent accidental contact of persons with live parts.

c. Dimmers shall be so connected that they will be dead when their respective circuit switches are open.

This means that on a three wire system with grounded neutral or on a two-wire system with one wire grounded, where the switch may disconnect only the ungrounded wire, the dimmer must be connected on that side of the circuit next the grounded conductor and thus be between the lamps and the grounded conductor.

d. Footlights shall be wired by either the conduit or the armored cable method, receptacles being inclosed in approved boxes, or the wires shall be encased in metal trough composed of No. 20 U. S. sheet metal gauge (.0375 inch), treated to prevent oxidation. Conductors shall be soldered to receptacle terminals, which shall be kept at least ½ inch from the metal of the trough.

e. Footlights, border lights and proscenium side lights shall be so wired that the number of outlets and the lamps connected to them shall in no case be such as to place more than 15 amperes on a branch-circuit fuse.

f. Borders and proscenium sidelights shall be constructed as prescribed in paragraph d of this section, 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.

g. Border cables shall be of approved type and suitably supported. They shall be employed only where flexibility is required.

h. Approved asbestos-covered (Type A) or slow-burning (Type SB) wire shall be used for wiring the border.

i. Stage and gallery receptacles shall be in approved pockets or inclosures and controlled from, and protected by individual cutouts at, the stage switchboard. Feeds for arc receptacles shall not be smaller than No. 6 and the receptacles shall have a capacity of not less than 35 amperes. Feeds for incandescent receptacles shall not be smaller than No. 12 and the receptacle shall have a capacity of not less than 15 amperes. Plugs for arc and incandescent receptacles shall not be interchangeable.

j. Lamps installed in scene docks shall be so located and guarded as to be free from mechanical injury.

k. Curtain motors shall be of the inclosed type.

l. Where stage flue dampers are released by an electrical device, the circuit operating the latter shall be normally closed, and shall be controlled by at least two approved single-pole switches inclosed in approved iron boxes having self-closing doors without locks or latches, one switch being placed at the electrician's station and the other where designated by the inspection department. 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 inclosed in a suitable iron box having a tight, self-closing door.

Order 1336.04. Dressing Rooms.

a. Approved conduit, electrical metallic tubing, surface metal raceways or armored cable shall be employed as the wiring method.

b. Pendants for lights shall be composed of approved reinforced cord, armored cable or armored cord.

c. Lamps shall be protected by approved guards sealed or locked in place.

Order 1336.05. Portable Arc Lamps.

a. Arc lamps shall be substantially constructed entirely of metal not less than No. 20 U. S. sheet metal gauge (.0375 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 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. Mica shall be used for the insulation of the lamp frame.

d. Arc-lamp frames and standards shall be so installed and guarded as to prevent their becoming grounded.

e. The switch on the standard shall be of such design that accidental contact with any live part will be impossible.

f. Stranded connections in lamp and at switch and rheostat shall be provided with approved lugs.

g. Rheostats shall be inclosed 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.

h. A qualified operator shall be employed for each lamp, or for each two lamps not more than 10 feet apart and so placed that one operator can properly watch and care for both.

Order 1336.06. Portable Bunches.

a. Substantial metal shall be employed and the wiring shall not be exposed.

b. Where the cable passes through the metal, an approved bushing shall be employed, and the cable shall be so anchored as to relieve the connections of any mechanical strain.

Order 1336.07. Portable Strips.

a. Portable strips shall conform to the requirements of paragraphs d, e, and f of Order 1336.03, of this Code.

b. Where the cable passes through the metal an approved bushing shall be employed, and the cable shall be so anchored as to relieve the connections of serious mechanical strain.

Order 1336.08. Portable Plugging Boxes.

a. The construction shall be such that no current-carrying part will be exposed.

b. Each receptacle shall have a current-carrying capacity of 30 amperes, and shall be protected by approved fuses mounted on slate or marble bases inclosed in a fireproof cabinet equipped with self-closing doors.

c. Bus bars shall have a current-carrying capacity equal to the sum of the ampere ratings of all the receptacles. Approved lugs shall be provided for the connection of the master cable.

Order 1336.09. Portable Switchboards.

a. Portable switchboards shall be supplied only from outlets specially provided for this purpose. Such outlets shall consist of externally operable, inclosed fused switches mounted on the stage wall or at the switchboard in locations readily accessible from the stage floor.

b. Portable switchboards shall be placed within an inclosure of substantial construction and may be so arranged that the inclosure is open during operation. Inclosures of wood shall be completely lined with sheet metal suitably protected from corrosion. Except as provided for dimmer face plates, there shall be no exposed live parts within the inclosure.

c. Portable switchboard supply shall be by means of an approved stage cable terminating within the switchboard inclosure in an externally operable, inclosed fused master switch arranged to cut off current to all apparatus within the inclosure except the pilot light. This cable shall be of sufficient capacity to carry the total load on the switchboard, and the master switch shall not be fused to exceed this capacity.

d. Conductors within the switchboard inclosure shall be of the stranded, asbestos-covered type inclosed in metal troughs or properly supported and securely fastened in position. Conductors shall have a carrying capacity not less than that of the switch or cutout which they supply. All conductors shall be bushed where they pass through metal inclosures and strands shall be soldered together before being fastened under clamps or binding screws. At terminals conductors of No. 6 and larger shall be soldered into lugs.

e. Stage cables shall be of approved type and shall be so arranged that strain shall be taken from clamps and binding screws. Cables shall be protected by metal bushings where they pass through metal or wood inclosures. The location, within the switchboard inclosure, of terminals or binding posts to which stage cables are connected shall permit convenient access to the terminals.

f. All switches shall be of the externally operable, inclosed type.

g. Fuses shall be of the plug or cartridge type and shall be provided with inclosures in addition to the switchboard inclosure. All circuits leaving the switchboard shall have a fuse in each conductor. Circuits directly supplying apparatus containing incandescent lamps shall be fused at not over 15 amperes and other circuits shall be fused in accordance with the current required by the circuit.

h. The terminals of dimmers shall be provided with approved inclosures, and dimmer face plates shall be so arranged that accidental contact cannot be readily made with the face plate contacts.

i. A pilot light shall be provided within the inclosure, 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 fused at not over 15 amperes.

Order 1336.10. Portable Conductors.

a. Pin-plug connectors shall be so designed that tension on the cable will not cause serious mechanical strain on the connections. The female half shall be attached to the live end of the cable.

b. Flexible conductors used from receptacles to arc lamps, bunches and other portable equipments shall be approved stage cable except that for the purpose of feeding a stand lamp under conditions where conductors are not liable to severe mechanical injury, an approved reinforced cord may be used, provided cutout designed to protect same is not fused over 15 amperes capacity.

Order 1336.11. Lights on Scenery.

a. Brackets shall be wired internally, and the fixture stem shall be carried through to the back of the scenery, where a suitable bushing shall be placed on the end of the stem. Fixtures shall be securely fastened in place.

Order 1336.12. String or Festooned Lights.

a. Joints in wiring shall be staggered where practicable.

b. Lamps inclosed in lanterns or similar devices shall be equipped with approved guards.

Order 1336.13. Special Electrical Effects.

a. Devices used for simulating lightning, waterfalls, etc., shall be so constructed and located that flames, sparks, etc., cannot come in contact with combustible material.

Order 1336.14. Grounding.

a. Where conduit, electrical metallic tubing, armored-cable or surface metal-raceway construction is employed, all such conduit, tubing, metal sheath, raceways, all exposed metal frames and inclosures of equipment, including bor-

ders, shall be grounded as prescribed in Section 103 of the code. This shall apply to all devices, except portable arc lamp standards, portable strips, and similar portable devices containing no wire of a grounded circuit over 150 volts and no wire of an ungrounded circuit exposed to higher voltages.

SECTION 133.7. RADIO EQUIPMENT, INCLUDING CENTRALIZED-DISTRIBUTION AND PUBLIC-ADDRESS SYSTEMS AND SPEECH-INPUT EQUIPMENT, ETC.

Order 1337.01. General.

a. The requirements of this section shall not apply to equipment installed on shipboard, in aircraft, or in other mobile stations, nor to equipment and antennas used for coupling carrier current to power line conductors; but shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive.

b. Except as otherwise permitted in this section, methods of wiring from the source of power to and between devices, related to apparatus connected to interior wiring systems, shall be in accordance with the rules covering permanent or portable fixtures, devices and appliances.

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 counter-poise conductors and that the National Electrical Safety Code, Part 5, be followed.

c. Except as otherwise permitted in this section, wiring for public address systems, speech input equipment, etc., and wiring for radio-frequency and audio-frequency amplifying equipment associated with radio receiving stations in centralized distribution systems, shall be in accordance with Section 136.0 of this code.

Order 1337.02. For Receiving Stations Only.

a. Outdoor antenna and counterpoise conductor sizes shall be not less than No. 14 if of copper or No. 17 if of bronze or copper-clad steel. Antenna and counterpoise conductors outside buildings shall be kept well away from all electric light or power wires of any circuit of more than 600 volts, and from railway, trolley or feeder wires, so as to avoid the possibility of contact between the antenna or counterpoise and such wires under accidental conditions.

b. Antenna and counterpoise where placed in proximity to electric light or power wires of less than 600 volts, or signal wires, shall be constructed and installed in a strong and durable manner, and shall be so located and provided

with suitable clearances as to prevent accidental contact with such wires by sagging or swinging.

c. Splices and joints in the antenna span shall be soldered unless made with approved splicing devices.

d. The preceding paragraphs, a, b, and c, shall not apply to light and power circuits used as receiving antenna, but the devices used to connect the light and power wires to radio receiving sets shall be of approved type.

e. Lead-in conductors, that is, conductors from outdoor antennas to protective devices, shall be of copper, approved copper-clad steel or other metal which will not corrode excessively, and in no case shall they be smaller than No. 14, except that bronze or copper-clad steel not less than No. 17 may be used.

f. Lead-in conductors from the antenna to the first building attachment shall conform to the requirements for antennas similarly located. Lead-in conductors from the first building attachment to the building entrance shall, except as specified in the following paragraph, be installed and maintained so that they cannot swing closer to open supply conductors than the following distances:

Supply wires 0 to 600 volts	2 feet
Supply wires exceeding 600 volts	10 feet

Where all conductors involved are supported so as to insure a permanent separation and the supply wires do not exceed 150 volts to ground, the clearance may be reduced to not less than 4 inches. Lead-in conductors on the outside of buildings shall not come nearer than the clearances specified above to electric light and power wires unless separated therefrom by a continuous and firmly fixed non-conductor which will maintain permanent separation. The non-conductor shall be in addition to any insulating covering on the wire.

g. Each lead-in conductor from an outdoor antenna shall be provided with an approved protective device (lightning arrester) which will operate at a voltage of 500 volts or less, properly connected and located either inside the building at some point between the entrance and the set which is convenient to a ground, or outside the building as near as practicable to the point of entrance. The protector shall not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to flammable gases or dust or flyings of combustible materials.

h. The grounding conductor from the protective device may be bare and shall be of copper, bronze or approved copper-clad steel, and if entirely outdoors shall not be smaller than No. 14 if of copper nor smaller than No. 17 if of bronze or copper-clad steel. If wholly indoors or with not more than ten feet outdoors it need not be larger than No. 18. The protective grounding conductor shall be run in as straight a line as possible from the protective device to a good permanent ground. The ground connections shall be made to a cold-water pipe where such pipe is available and is in service and connected to the street mains. An outlet pipe from a water tank fed from a street main or a well may be used, provided such outlet pipe is adequately bonded to the inlet pipe connected to the street water main or well. If water pipes are not available, ground connections may be made to a grounded steel frame of a building or to a grounding electrode, such as a galvanized iron pipe or a rod driven into permanently damp earth or to a metal plate or other body of metal buried similarly. Gas piping shall not be used for the ground.

i. The protective grounding conductor shall be guarded where exposed to mechanical injury. An approved ground clamp shall be used where the protective grounding conductor is connected to pipes or piping.

j. The protective grounding conductor may be run either inside or outside the building. The protective grounding conductor and ground, installed as prescribed in the preceding paragraphs h and i, may be used as the operating ground.

It is recommended that in this case the operating grounding conductor be connected to the ground terminal of the protective device. If desired, a separate operating grounding connection and ground may be used, this operating grounding conductor being either bare or provided with an insulated covering.

k. Wires inside buildings shall be securely fastened in a workmanlike manner and except as provided in paragraph m of this order shall not come nearer than two inches to any electric light or power wire not in conduit unless separated therefrom by some continuous and firmly fixed non-conductor, such as porcelain tubes or approved flexible tubing, making a permanent separation. This non-conductor shall be in addition to any regular insulating covering on the wire.

l. Storage-battery leads shall consist of conductors having approved rubber insulation. The circuit from a filament, "A," storage battery of more than 20 ampere-hours capacity, NEMA rating, shall be properly protected by a fuse or circuit-breaker rated at not more than 15 amperes. The circuit from a plate, "B," storage-battery shall be properly protected by a fuse or circuit-breaker rated at not more than one ampere in the negative lead. Fuses or circuit-breakers shall be located not more than 18 inches along the wire from a battery terminal.

m. Under conditions noted in sub-paragraphs 1, 2, 3 and 4 below, wiring for radio systems, public-address systems, or speech-amplifier systems may be grouped in the same conduit, armored cable, electrical metallic tubing, metal raceway, pull box, junction box, cabinet or flexible cord.

1. Power-supply wires are introduced solely for supplying the equipment to which the other wires are connected.

2. Flexible cords are of types P, POSJ, K, S, or SJ or other type especially approved for the purpose in which wires other than power-supply wires are insulated individually or collectively in groups by insulation at least equivalent to that on the power-supply wires.

3. Wires other than power-supply wires run in conduit, armored cable, electrical metallic tubing, metal raceway, pull box, junction box, or cabinet with power-supply wires are insulated individually or collectively in groups by insulation at least equivalent to that on the power-supply wires, or the power-supply and other wires are separated by a lead sheath or other continuous metallic covering.

4. Terminals for the power-supply conductors and the other conductors provide spacings of all other terminals from the power terminals at least as great as the spacing between power terminals of opposite polarities and also suitable means are provided to guard against connecting other conductors to the power-supply terminals.

n. Radio receiving sets connected to power supply systems shall be supplied either through double pole switches or through polarized plugs and receptacles. The grounded lead shall be free from automatic overload protective devices.

Order 1337.03. For Transmitting Stations Only.

The following paragraphs apply to amateur transmitting stations.

a. Antenna and counterpoise conductors outside buildings shall be kept well away from all electric light or power wires of any circuit of more than 600 volts, and from railway trolley or feeder wires, so as to avoid the possibility

of contact between the antenna or counterpoise and such wires under accidental conditions. Antenna and counterpoise conductors where placed in proximity to electric light or power wires of less than 600 volts, or signal wires, shall be constructed and installed in a strong and durable manner, and shall be so located and provided with suitable clearances as to prevent accidental contact with such wires by sagging or swinging.

b. Antenna conductor sizes shall be not less than given in the following table:

Material	Stations to which power supplied is less than 100 watts and where voltage of power is less than 400 volts	Stations to which power supplied is more than 100 watts or voltage of power is more than 400 volts
Soft copper	14	7
Medium-drawn copper	14	8
Hard-drawn copper	14	10
Bronze or copper-clad steel	14	12

c. Splices and joints in the antenna and counterpoise span shall be soldered unless made with approved splicing devices.

d. Lead-in conductors shall be of copper, bronze, approved, copper-clad steel or other metal which will not corrode excessively and in no case shall be smaller than No. 14.

e. Antenna and counterpoise conductors and wires leading therefrom to ground switch, where attached to buildings, shall be firmly mounted five 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 five inches creepage and air-gap distance to flammable or conducting material, except that the creepage and air-gap distance for continuous-wave sets of 1000 watts and less input to the transmitter, shall be not less than 3 inches.

f. In passing the antenna or counterpoise lead-in into the building, a tube slanting upward toward the inside, or a bushing of non-absorptive insulating material shall be used, and shall be so insulated as to have a creepage and air-gap distance in the case of continuous wave sets of 1000 watts and less input to the transmitter, not less than three inches, and in all other cases not less than five inches. Fragile insulators shall be protected where exposed to mechanical injury. A drilled window pane may be used in place of a bushing provided the creepage and air-gap distance, as specified above, are maintained.

g. Adequate lightning protection either in the form of a grounding switch or suitable lightning arrester shall be provided. The grounding conductor for such protection shall be at least as large as the lead-in and in no case smaller than No. 14 copper, bronze, or approved copper-clad steel. The protective grounding conductor need not have an insulating covering or be mounted on insulating supports. The protective grounding conductor shall be run in as straight a line as possible to a good permanent ground suitable for the purpose. The protective grounding conductor shall be protected where exposed to mechanical injury.

h. The operating grounding conductor where used shall be of copper strip not less than ⅜ inch wide by $\frac{1}{32}$ inch thick, or of copper bronze, or approved copper-clad steel having a periphery, or girth, of at least ¾ inch, such as a No. 2 wire, and shall be firmly secured in place throughout its length.

i. The operating grounding conductor shall be bonded to a good permanent ground. Preference shall be given to water piping. Other permissible grounds are grounded steel frames of buildings or other grounded metal work in the building, and artificial grounding devices such as driven pipes, rods, plates, cones, etc. Gas piping shall not be used for the ground.

j. The transmitter shall be inclosed in a metal frame, or grill, or separated from operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.

k. All external metallic handles and controls accessible to the operating personnel shall be effectually grounded.

No circuit in excess of 150 volts should have any parts exposed to direct contact. A complete dead-front type of switchboard is preferred.

l. All access doors shall be provided with interlocks which will disconnect all voltages in excess of 750 volts when any access door is opened.

m. Under the conditions noted in pargraphs 1, 2 and 3 below, wiring may be grouped in the same conduit armored cable, electrical metallic tubing, metal raceway, pull-box, junction-box or cabinet.

1. Power-supply wires are introduced solely for supplying power to the equipment to which the other wires are connected.

2. Wires other than power-supply wires run in conduit, armored cable, electrical metallic tubing, metal raceway,

pull-box, junction-box or cabinet with power-supply wires are insulated individually or collectively in groups by insulation at least equivalent to that on the power-supply wires or the power and other wires are separated by a lead sheath or other continuous metallic covering.

3. Terminals for the power supply conductors and the other conductors provide spacings of all other terminals from the power terminals at least as great as the spacing between power terminals of opposite polarities and also suitable means are provided to guard against connecting other conductors to the power supply terminals.

n. Conduits, wireways, busways or raceways for the installation of wires and cables and groups or combinations of wires and cables, shall be of such size that the sum of the cross-sectional areas of the several conductors, including insulation, will be not more than 40 per cent of the interior cross-sectional area of the conduit, wireway, busway or raceway. The number of wires need not be otherwise limited.

SECTION 133.8. SIGNS AND OUTLINE LIGHTING

Order 1338.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, of this Code.

Order 1338.02. Material.

a. Metal used in the construction of sign boxes, cabinets or outline troughs shall be not less than No. 28 U. S. sheet metal gauge (.0156 inch). It shall be galvanized or otherwise suitably protected from corrosion.

b. With the exception of wood employed for the external decoration of signs and kept at least 2 inches distant from the nearest socket or receptacle, signs shall be constructed entirely of metal or other approved non-combustible material. These limitations shall not apply to portable signs nor to other portable illuminated devices.

c. The design shall be such as to afford ample strength and rigidity, to inclose all terminals and wiring other than the leads, except as provided in Order 1338.05 of this section, and for outdoor signs or outline troughs to render the box or trough practically weatherproof and to provide drainage for each compartment by means of one or more holes, each not less than ¼ inch in diameter.

d. Cutouts, flashers, and other similar devices placed on or within the body or structure of a sign on or in a building shall be inclosed in approved cabinets or cutout boxes, the doors of which shall be arranged so that they can be opened without removing obstructions or finished parts of the sign. When exposed to the weather these cabinets or cutout boxes must be weatherproof. Non-weatherproof transformers, if outside of buildings, shall be placed in such cabinets or cutout boxes.

Order 1338.03. Sockets and Receptacles.

a. Sockets and receptacles for sign and outline lighting shall be of the keyless porcelain or moulded composition type, and shall be so designed as to afford permanent and reliable means to prevent turning. Terminals of sign receptacles shall be kept at least ½ inch from metal of the sign; provided, however, that where open work is employed as the wiring method outside buildings, this separation shall be at least 1 inch. Miniature receptacles shall not be employed for outdoor work.

b. Electric signs with changeable connections shall be so arranged that the connections can be changed manually only by approved connectors. Approved connectors shall interrupt all ungrounded conductors of the circuit.

Order 1338.04. Wiring.

a. Wire of approved rubber-covered type (Type R) not smaller than No. 14, shall be used except that for portable signs the conductor may be as small as No. 18 and except also where in portable signs the wiring is subject to temperatures higher than 120° F. (49° C.) the insulation shall be of an approved heat-resisting type.

All portable signs shall be considered to be for indoor use only.

b. Wires shall be neatly run, and so disposed and fastened as to be mechanically secure.

c. Wires shall be soldered to terminals of receptacles, and exposed parts of wires and terminals shall be treated to prevent corrosion.

These requirements shall not be applied to portable signs.

d. Approved bushings shall be employed to protect wires passing through walls or partitions of the structure. Sign leads not encased in conduit or metal armor may be cabled before passing through non-combustible, non-absorptive bushings.

e. Wires on the outside of sign structures or outline wiring, shall, except as provided in Order 1338.05 of this section, be inclosed in approved rigid or flexible conduit, armored cable, electrical metallic tubing or metal troughs. When used on the outside of a building, the conduit or other inclosures shall be made raintight or the wires shall be lead covered.

f. Outline lighting shall be protected by its own cutout and controlled by its own switch.

g. Circuits shall be so arranged that the number of outlets and the lamps connected to them shall in no case be such as to place more than 15 amperes on the branch circuit fuse.

h. Live parts shall be inclosed or otherwise guarded unless on grounded circuits of not more than 150 volts to ground, and safe from accidental contact by objects or persons.

Order 1338.05. Open Wiring.

a. Open work may be employed as the wiring method for outline lighting and for signs on walls, roofs or open ground, where not subject to mechanical injury, and not readily accessible to unauthorized persons and if on grounded circuits of not more than 150 volts to ground.

b. Where wires are connected to approved receptacles which hold them at least 1 inch from the surface wired over, and which are placed at intervals not exceeding 1 foot, the receptacles themselves shall be considered to afford the necessary support and spacing of the wires. Where the interval between receptacles exceeds 1 foot but is less than 2 feet, an additional non-combustible, non-absorptive insulator maintaining a separation and spacing equivalent to the receptacles shall be used.

c. Where flexible tubing must be employed in outline lighting, the ends shall be sealed and painted with a moisture repellant and the tubing shall be kept at least ½ inch from the surface wired over.

Order 1338.06. Grounding.

a. Signs, troughs and other metal frames shall be grounded as provided in Section 103 of this Code, unless these are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons.

Order 1338.07. Switches.

a. Switches controlling sign or outline wiring shall be externally operable.

b. Each sign shall be provided with a switch which will open all ungrounded wires supplying the sign. When signs are not within sight of the switch, the switch shall be of the locking type.

Order 1338.08. Gas Tube Systems for Signs, Outline Lighting and Interior Lighting.

a. The tube shall be substantially supported and so installed as to be free from contact with flammable material, or for voltages exceeding 7500 volts, grounded metal objects. It shall not be unduly exposed to mechanical injury. Tube terminals shall comply with one of the following provisions:

1. They shall project within the sign inclosure; or
2. They shall be isolated from combustible material and inaccessible to unauthorized persons; or
3. For exposed signs in show windows they shall be entirely surrounded by glass or porcelain and the high-tension leads shall be approved for the purpose or shall be encased in a substantial glass tube or equivalent insulation so that no part of such lead or the metal terminal is exposed to contact; or
4. They shall be installed in separate inclosures approved for the purpose which shall consist of non-combustible non-absorptive insulating material or of metal of thickness not less than No. 24 U. S. sheet-metal gauge. Such sheet metal shall be galvanized, treated with at least three coats of anti-corrosive paint, or otherwise suitably protected from corrosion. Connections at electrodes shall be mechanically and electrically secured and, unless a solderless connector approved for the purpose is used, shall be soldered.

Rubber tape alone surrounding high-tension leads is not considered sufficient insulation.

b. The transformers, tubes and other apparatus shall be approved for this use. High-voltage transformers of other than weatherproof type, and other high-voltage equipment shall be installed in approved metal boxes unless placed within the metal boxes provided for the tube terminals. The transformer secondary open-circuit voltage shall not exceed 15,000 volts with an allowance on test of 1,000 volts additional.

c. High-voltage conductors shall be approved for the purpose and shall be not smaller than No. 14. Outside of the cabinets and tube-terminal inclosures they shall be covered with insulation approved for the purpose. Where within

reach from ground, roof or window, they shall be installed in metal conduit. Elsewhere, if indoors, they shall be run in conduit, unless they can hang vertically and free from possibility of contact; and if outdoors they shall be run in conduit or on approved insulators which maintain a separation of at least two inches from other objects. Where high-voltage conductors leave conduit, the insulation shall extend at least two inches beyond the conduit.

d. Not more than one transformer shall be dependent upon a single automatic overcurrent protective device unless the combined load is less than 1650 volt-amperes. Additional devices for the individual protection and disconnection of transformers in signs may be placed within or outside the sign structure. If exposed to the weather, they shall be of weatherproof type.

e. Inclosures for transformers and regulating coils shall be well ventilated and of such design as to prevent the emission of any flame or sparks in case of burnout of any of the coils. All metal inclosures even though portable shall be permanently and effectively grounded in accordance with Section 103, except that a No. 14 wire may be used for bonding together isolated tube-terminal boxes or outline systems. Transformer cases shall be marked with maker's name, input capacity in amperes or volt-amperes, low-tension voltage, and open-circuit high-tension voltage.

f. Uninsulated high-voltage parts of a portable sign or a sign intended for indoor use shall be wholly inaccessible, or the inclosure shall be provided with an interlock switch or switches arranged so that the opening of any door or cover giving access to such high-voltage parts will positively cause the breakage of the primary circuit.

g. Signs of the gas-tube type shall comply with the provisions for illuminated signs in the previous orders of this section in addition to the requirements of this order.

h. All Neon signs not coming within the definition of portable shall be wired in accordance with the code rules. Satisfactory portable signs may be installed by connection with portable cord.

As applied to neon signs, portable means less than 75 lbs. in weight and 10 square feet over the largest surface, with all high tension wires and tube terminals within the sign inclosure proper, and the tubes or lamps fastened only to and not extending beyond the sign surface or back-ground. All portable neon signs shall have the metal inclosure 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 1338.09. Accessibility.

a. Electric signs at an elevation greater than 30 feet above roadways or footways, or at an elevation above a roof greater than the distance from the edge of the roof, shall, if they require attendance while in position, be provided with substantial, safely accessible runways, ladders or platforms from which all replacements and other necessary adjustments can be made. Provisions for supporting workmen by safety belts should be made in the construction and installation of signs so located.

SECTION 133.9. ORGANS

Order 1339.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0 inclusive, of this Code. They shall be deemed to apply to those electrical circuits and parts of electrically operated organs which are employed for the control of the sounding apparatus and keyboards.

Order 1339.02. Source of Energy.

a. The source of energy shall be either a self-excited generator rated at not over 15 volts, or a primary battery.

b. The generator shall either be permanently and effectively insulated both from ground and from the motor driving it, or both generator and motor frames shall be grounded as prescribed in Section 103 of this Code.

Order 1339.03. Cables.

a. All wires, except common return wires and wires inside the organ proper, the organ sections and the organ console, shall be cabled.

b. The separate wires of the cable shall be not smaller than No. 26, and shall have either rubber, cotton or silk insulation. The cotton or silk may be saturated with paraffine, if desired.

c. The separate wires shall be either bunched or cabled. In either event they shall be inclosed in one or more braided outer coverings. A tape may be substituted for an inner braid. The outside covering of a cable not run in conduit shall either be flameproof, or covered with a closely wound fireproof tape.

d. The common return wire shall be not smaller than No. 14, shall be of either the rubber-covered type, Type R, the asbestos-covered type, Type A, or the slow-burning type,

Type SB, and shall not be contained in the cable. It may be run in contact with the cable or placed under an additional covering inclosing both cable and return wire.

Order 1339.04. Workmanship and Material.

a. All wiring and devices within the organ or any of its parts shall be neatly disposed and securely fastened.

It is not found to be either necessary or feasible in organ structures to require the use of non-combustible, non-absorptive insulating material for the supports or inclosures of current-carrying parts.

b. Cables between parts of the organ and between the console and the organ shall be installed in a workmanlike manner, shall be securely fastened in position and shall be kept from contact with other wires. Conduit may be used, but shall not be required.

Order 1339.05. Fuses.

a. Feed wires shall be protected at the source by a fuse of suitable capacity, and, except common return wires, shall be so subdivided and protected at the organ sections or distribution points by approved fuses of not over 15 amperes rating that every wire will be protected by one or more such fuses.

SECTION 134.0. ISOLATED PLANTS, 0–50 VOLTS

Order 1340.01. General.

a. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, of this Code.

b. This section shall be deemed to apply particularly to isolated plants which employ as their prime mover a stationary internal-combustion engine, with its necessary fittings, connected to an electric generator either with or without an auxiliary storage battery with its control devices, and operating at a potential of less than 50 volts.

c. Attention shall be given to the relatively low voltage at which these plants operate, thus requiring a greater current for equivalent energy and making necessary a greater ampere capacity of conductors, fittings, devices and appliances as compared with those of the standard 0–600 volt classification used on commercial circuits.

Order 1340.02. Sockets and Receptacles.

a. Standard lamp sockets and receptacles of the 660-watt classification shall be used. In designing circuits, each lamp

socket or receptacle shall be assumed to have a load of not less than 40 watts.

b. Receptacles of 20 ampere rating shall be provided in kitchens, laundries, and similar locations where appliances are likely to be used.

Order 1340.03. Automatic Cutouts and Circuits.

a. The fuses in the branch circuit shall not exceed 20 amperes rating except for special circuits as in paragraph c of this section.

b. Fuses shall be so placed that no set of small motors, small heating appliances or incandescent lamps, nor more than 8 lamp sockets or receptacles, requiring more than 320 watts, shall be dependent upon one cutout.

c. Wire size shall be not less than No. 12 for any circuits. For special circuits to which appliances or appliance receptacles are attached, as in paragraph b of Order 1340.02 of this section, the wire size shall be not less than No. 10 for supplying more than one appliance or appliance outlet.

Order 1340.04. Batteries.

a. Batteries shall be located in rooms or spaces having natural means of ventilation.

b. 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 1340.05. Grounding.

a. The grounding of frames of engines or generators is not required. One of the circuit wires shall be grounded where wires are run overhead between buildings.

SECTION 134.1. EMERGENCY LIGHTING

Order 1341.01. General.

a. The provisions of this section shall apply to systems or circuits for supplying emergency illumination only when such systems or circuits are required by municipal, state or other codes. See however, 1336.01c.

b. The requirements of this section shall be deemed to be additional to, or amendatory of, those prescribed in Sections 130.1 to 132.0, inclusive, and Sections 134.0 and 135.0, in so far as they apply, of this Code.

c. Emergency illumination shall be deemed to include all required exit lights and all other lights specified as necessary to provide sufficient illumination to enable persons to leave the building safely.

Order 1341.02. Emergency Lights.

a. Lights shall be provided and so located and supplied as to provide, with one supply interrupted, emergency illumination without appreciable delay. This would ordinarily require either:

1. 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, or

2. 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 1341.03. Current Supply.

a. Supply shall be provided for emergency illumination from at least two separate and independent sources, which may include:

1. Services as widely separated, electrically and physically, as the available facilities allow, or

2. 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), or

3. 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.

Order 1341.04. Tests.

a. Systems shall be operated and tested sufficiently frequently to assure their maintenance in proper operating condition and batteries shall be maintained in full charged condition.

It is recommended that inspection authorities having jurisdiction conduct a test on the complete system upon installation and periodically afterward.

Order 1341.05. Systems Under 50 Volts.

a. Where a source of supply at less than 50 volts is employed as one of the systems, the installation shall also comply with appropriate provisions of Section 134.0 of this code.

Order 1341.06. Signals.

a. 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 set are carrying the emergency illumination load.

Order 1341.07. Fuses.

a. No fuses other than service fuses shall be placed ahead of the branch-circuit fuses for circuits carrying lights for emergency illumination; these branch-circuit fuses shall be accessible to authorized persons only.

Order 1341.08. Control.

a. Lights for emergency illumination shall not be connected to or controlled by a stage lighting control but from a switch accessible only to authorized persons, preferably located in the lobby or other convenient place in the front of the building. No other manual control or switch shall be inserted in circuits carrying emergency illumination other than a switch at the main service or on the control panel of a special current source.

Order 1341.09. Independent of Other Lights.

a. Except as permitted in sub-paragraph 2 of paragraph a of Order 1341.02, wiring for lights for emergency illumination 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.

SECTION 135.0. CIRCUITS AND EQUIPMENT OPERATING AT MORE THAN 600 VOLTS BETWEEN CONDUCTORS

The requirements of this section shall be in addition to or amendatory of those prescribed in Sections 130.1, 130.2, 130.3, 130.5 to 132.0, inclusive, 133.2 and 133.8 of this Code.

See Section 133.8 for provisions for Gas Tube Systems, formerly Order 1350.02 of this section.

See Section 135.1 for provisions for X-Ray and High-Frequency Apparatus, formerly Order 1350.12 of this section.

Order 1350.01. Series Arc Lighting.

a. Elsewhere than in central stations, substations and transformer vaults, constant-current systems shall not be

installed in buildings, and lamps or fixtures shall not be attached to exterior walls of buildings, except by permission of the authority enforcing this code.

Order 1350.02. Wiring.

a. Circuits operating at more than 7500 volts between conductors shall not (except as provided in Sections 133.8 and 135.1 of this code) be installed in buildings other than central stations, substations, transformer vaults and fire-resistive motor rooms. Industrial substations for such voltages, if not outdoors or in separate detached buildings, shall meet the requirements for transformer vaults in Order 1350.06. Conductors, other than service conductors supplying service equipment within the building, of circuits operating at 7500 volts or less between conductors and which are on the supply side of the service equipment which they supply shall be similarly restricted as to location. See paragraph i of Order 1350.08.

b. Elsewhere than in central stations, substations, generator, transformer, switching, and motor rooms, conduits shall properly enter and be secured to the casing or shields surrounding apparatus or to suitable terminal boxes bolted or otherwise secured to the casing.

c. Elsewhere than in central stations, substations, and generator, transformer, switching and motor rooms and in service runs, all wiring of circuits of more than 600 volts shall be in the form of cable approved for the rated voltage of the circuit run in rigid conduit or duct. If the cable is not lead-sheathed, it shall be run in rigid metal conduit. In cases where lead-sheathed cable is used, the sheath need not be continued over the splices where moisture is absent; but where the metal sheath is used over the rest of the cable, the ends of the sheath shall be belled out and bonded around the splices by No. 6 copper wire and ground clamps.

d. Where a cable emerges from its metal sheath, the insulation of the several conductors shall be thoroughly protected from moisture and mechanical injury by a pothead or equivalent device.

e. Where open work is employed in generator, transformer, switching, and motor rooms in other than central stations and substations, the conductors shall be rigidly supported on glass, porcelain, or other insulators approved for the purpose which will keep them at least eight inches apart, except at apparatus and devices, and at least two inches from the surface wired over in all cases, and three inches where voltage exceeds 2500.

Where open conductors with insulating covering are closely grouped and the installation is subject to damage from arcs or hot parts if nearby conductors are short-circuited, such insulation shall be protected by a substantial flameproof outer covering. This flameproof covering shall be stripped back from terminals a sufficient distance to provide proper insulation for the voltage concerned.

Conductors and their supports, including insulators, shall have strength and stability sufficient to insure maintenance of adequate clearance in case of possible short-circuit current.

Rigid supporting requires supports about 4½ feet apart when wiring along flat surfaces under ordinary conditions.

f. Overhead service conductors shall be not smaller than No. 6, or if in cable shall be not smaller than No. 8. They shall enter the building only in rigid conduit, or as separate individual wires, or as multiple-conductor cable approved for the purpose. Where rigid conduit is used, it shall have weatherproof threaded joints and be equipped with an approved service pothead. Where open wires are used the separate individual wires may enter through approved roof bushings or shall have drip loops formed on them and shall then pass upward and inward through slanting non-combustible, non-absorptive insulating tubes or bushings. In either case the open wires shall be guarded where accessible to unqualified persons.

g. Underground service conductors shall be not smaller than No. 8 and shall be lead-covered or other type of cable approved for the purpose. If lead-covered cable is used for voltages exceeding 2500 volts to ground, it shall terminate in suitable potheads or their equivalent, located to conform with Order 1350.09. The end of underground service conduit shall be sealed with suitable compound.

Order 1350.03. Motors.

a. Motors operating at more than 7500 volts between conductors shall not be installed elsewhere than in central stations and substations and in fire-resistive motor rooms.

Order 1350.04. Transformers and Apparatus.

a. Transformers installed in central stations and substations shall be so located that fire and smoke from burning coils or boiling oil will be unlikely to do harm.

It is recommended that air-cooled transformers be isolated as much as possible, and that, if air blast is employed, the ducts be fireproof.

It is further recommended that oil-filled transformers be placed in a compartment constructed in accordance with Order 1350.06 of this Code.

b. Transformers shall not be installed in buildings other than central stations or substations, except by permission of the authority enforcing this code. Where such permission has been granted, transformers shall be located as near as possible to the point at which the primary wires enter the building and shall be contained in an inclosure of fire-resistive material large enough to provide an air space of at least 6 inches on every side of the transformers. This inclosure shall be securely locked, access being allowed only to authorized persons, and shall be thoroughly ventilated. This shall not apply to the control-circuit transformer furnished with control equipment. These transformers shall be considered as subject to the requirements applying to the equipments with which they are used.

It is recommended that ventilation be secured by means of a chimney or flue leading out of doors.

c. Transformer cases shall be grounded as prescribed for the grounding of equipment in Section 103 of this code; provided, however, that cases or frames of transformers used exclusively to supply current to switchboard instruments need not be grounded if they are installed and guarded as required for the maximum potential at which they operate and provided that transformers mounted on wooden poles at a height of more than eight feet from the ground need not be grounded.

d. For oil-filled transformers which are not located in central stations or substations, the inclosure required by paragraph b of this section shall consist of fireproof vault construction in accordance with Order 1350.06.

e. For transformers in electric furnace rooms the requirements of this section and of Order 1350.06 shall be followed so far as practicable, provided, however, that by permission of the authority enforcing this code, oil-filled transformers having a total rating of 75 k. v. a. or less, may be located in electric furnace rooms of fire-resisting construction, if surrounded by concrete curbs not less than 6 inches high and forming a basin of sufficient capacity to retain all the oil used in such transformers.

This is to guard against the possibility of molten metal from the furnace coming in contact with the transformer casing, and also to prevent oil from the transformers reaching the furnace.

Order 1350.05. Control and Protective Equipment.

The following paragraphs apply only to circuits and apparatus supplied through the service equipment specified in Order 1350.08 of this Section.

a. When operating at more than 600 volts, each motor, each transformer or bank of transformers operating as a unit, and each other operating unit of apparatus shall, except as permitted in paragraph h, be separately controllable; and protected by a manually operable circuit-breaker which interrupts all ungrounded circuit wires and which is automatically actuated by excessive overcurrent in any ungrounded wire, and the number of overcurrent units shall be as specified in the table of paragraph o of Order 1308.06 of Section 130.8.

b. Where a motor-starting device does not open all ungrounded leads to the motor, the circuit-breaker specified above shall be installed in sight of the person operating the motor-starting device or else have provision for locking in the open position.

c. Transformers operating in multiple shall not be considered as operating in bank and shall be separately protected on both the primary and secondary side. When a generator and a transformer, or bank of transformers, operate as a unit for stepping up or stepping down the voltage, they may be controlled and protected as an operating unit.

d. Oil circuit-breakers and switches shall be isolated from other switches and electrical apparatus wherever practicable. Where connected to circuits exceeding 2500 volts to ground they shall be placed in separate fireproof cells or closed metal compartments and controlled from outside such closed compartments. Electrical or mechanical means shall be provided to indicate whether oil circuit-breakers are open or closed.

It is recommended that switches of the oil-immersed type used to control transformers be located in a vault, preferably separate from the transformers.

Safety control truck panels and metal-clad switch-gear units on circuits not exceeding 15,000 volts are considered to comply with this rule even though the circuit-breaker is not of the remote-control type.

e. Series trip coils connected directly to the circuit, unless adequately guarded or isolated by elevation, should not be used with panel or panel-frame-mounted oil circuit-breakers on circuits exceeding 750 volts.

f. Switches and control apparatus on circuits exceeding 2500 volts to ground shall be installed in a vault complying with Order 1350.06, or in a fire-resistive switch room or motor room.

Safety control truck panels and metal-clad switch-gear units are considered to comply with this rule.

g. All switches including disconnectors shall be so located that the point from which they are operated is safely accessible to qualified and authorized persons. Barriers should be provided on both sides of isolating switches. Unless interlocking arrangements are provided, signs shall be installed at isolating switches warning against opening them while they are carrying current.

h. Oil-filled or other suitable types of fuses may be used on circuits not exceeding 2500 volts to ground and rated at not more than 300 amperes or not exceeding 7500 volts and 100 amperes, for the following purposes:

1. 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 operable circuit-breaker between the point of origin of such circuits and the source of supply.

2. For the protection of individual transformers or banks of transformers operating as a unit when such transformers are supplied by a common feeder, provided that such feeder at the point where it receives its supply shall be protected by a manually operable or remote-control circuit-breaker. A circuit supplying a single transformer or bank of transformers need not have circuit-breaker protection.

3. For the protection of motors and their controllers and protective devices against short-circuit or locked-rotor currents, provided such controllers are automatically actuated through time-element overcurrent relays or other similar protective devices and open all ungrounded wires simultaneously, and are provided with the number of overcurrent units as specified in table of paragraph c of Order 1308.08.

4. For the protection of apparatus other than motors and transformers by special permission.

i. Fusible cutouts shall be so installed that the blowing of the fuse will not result in injury to persons or damage to other equipment.

Order 1350.06. Transformer Vaults.

Not applicable to central stations and substations in buildings used for no other purpose.

a. The walls and also the roof shall consist of reinforced concrete not less than six inches in thickness, or of brick not less than eight inches in thickness, or of construction of equivalent ruggedness and equivalent fire rating as determinated by tests conducted according to the Standard Fire Test Specification; except that when the total transformer capacity so inclosed is not over 100 kilovolt-amperes the above thickness may be reduced to four inches provided approved fireproof material is employed and the construction of the vault is specifically approved by the inspection department.

It is recommended that outside walls of the building, if of fireproof construction, constitute one or more of the walls of the vault or inclosure.

b. The inclosure shall be provided with means for ventilation which will prevent the development of room temperatures in excess of those at which the transformers installed therein may be safely operated. Temperatures shall be determined as prescribed in the standards of the American Institute of Electrical Engineers, and temperatures under full load shall not exceed the values there given. All ventilating openings not connected to chimneys or flues or directly to outside air shall be provided with automatic dampers made of metal of thickness not less than No. 10 (U. S. standard gauge for sheet steel) to prevent the emission of smoke or fire. Openings for illumination or ventilation shall be protected by louvres or by substantial fixed metal screens with mesh not larger than one inch, and shall be so constructed that snow or rain will not reach wiring or apparatus of other than weatherproof construction.

It is recommended that damper controls be arranged to be operated from a point outside the vault.

c. Where practicable, a suitable drain shall be provided which will carry off any accumulation of oil or water that may collect in the vault. Floor and drain shall have a pitch of not less than ¼ inch per foot. In vaults containing transformers having a total capacity of 100 kilovolt-amperes or less the drain may be omitted if the enclosure is so constructed as to retain all the oil used within the vault.

d. Any doorway leading from the vault into the building shall be thoroughly closed by means of a tight-fitting fire

door approved for openings in Class A situations as defined in the Regulations of the National Board of Fire Underwriters for the Protection of Openings in Walls and Partitions Against Fire. A door sill not less than four inches in height shall be provided. In all cases the sill shall be of sufficient height to confine within the vault the oil from the largest transformer installed. Entrance doors shall be equipped with locks where necessary to prevent unauthorized access. Doors, if equipped with spring or other automatic locks, shall be so arranged that they may be readily and quickly opened from the inside.

e. Pipes for water, steam, gas, sewers, or other purposes and such accessories as faucets and sprinkler heads and ducts for ventilating other parts of the building should not be installed in transformer vaults. Where conditions are such that the presence of these pipes cannot be entirely avoided, they shall be so located or so protected by non-flammable waterproof barriers as to prevent any leakage or moisture from condensation reaching high-voltage wiring or apparatus, and such pipes shall be installed without valves or traps within the vault or room.

Order 1350.07. Capacitors (Static Condensers).

a. Capacitors of the type made up of small units, separately or collectively protected by adequate fuses, may be installed in powerhouses or factory buildings if combustibles are kept well away from them; provided that if flammable oil is used, each unit shall contain not more than three gallons in a container made substantially oil-tight without use of solder (although use of solder to prevent slight seepage of oil is not prohibited). In rooms containing combustible dust or flying material, capacitors shall be enclosed.

If capacitors are accessible to other than qualified persons a non-combustible grille or guard around them may be desirable.

b. Capacitors containing flammable oil, but not meeting the requirements of the previous paragraph, shall be installed as specified for transformers in Order 1350.04 of this Section.

Certain other regulations define flammable and non-flammable liquids according to the flash-point. In the foregoing, however, the term "flammable" means oil or liquid that will burn.

c. For transformers used with capacitors, the requirements of Order 1350.04 shall be followed; provided, however, that by permission of the authority enforcing this code, oil-filled transformers intended for and used only with capacitor installations and not subject to lightning disturbances may be installed in rooms of non-combustible construction and occupancy. Such transformers shall be of sufficient capacity to allow for ordinary rises in voltage; they shall be surrounded by concrete curbs not less than six inches high which form a basin of sufficient capacity to retain all the oil contained in the transformers; and be protected by a circuit-breaker (or other overcurrent protective device and switch) set to operate at a current corresponding to not over 150 per cent of the rated capacity of the capacitor.

Order 1350.08. Service Equipment.

Note. Secondary conductors and not 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 Order 1350.06 and under the sole control of the supply company.

This order or Order 1304.05 will then apply to the service conductors and service equipment according as the voltage of the service conductors is or is not more than 600 volts. In no case will the provisions of this order, except paragraph g, 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.

a. In services operating in excess of 600 volts, all ungrounded conductors supplying equipment, except as noted below in paragraphs b and c, shall be controlled and protected by an automatic circuit-breaker of suitable rupturing capacity having an overcurrent device in each ungrounded conductor so arranged that the operation of any one device will open all ungrounded conductors.

b. On services entering fireproof transformer vaults, where the voltage is less than 25,000 between conductors, and where the transformer capacity (plus any other load supplied through the service conductors) does not exceed 200 kva. per phase, the following protective devices shall be provided:

1. An automatic circuit-breaker; or
2. A non-automatic oil switch with suitable fuses.

If the capacity exceeds 200 kva. per phase, an automatic circuit-breaker shall be provided.

c. On services entering fireproof transformer vaults, where the voltage is not more than 4500 between conductors,

and the transformer capacity (plus any other load supplied through the service conductors) does not exceed 100 kva. per phase, the following protective devices shall be provided:

1. An automatic circuit-breaker; or
2. A non-automatic oil switch with suitable fuses; or
3. Suitable fuses.

If the capacity exceeds 100 kva. per phase, see paragraphs a and b of this order.

d. A lightning arrester complying with the requirements of Order 1319.01 of Section 131.9 of this code shall be placed on each ungrounded overhead service conductor ahead of the other service equipment, when required by the authority enforcing this code.

e. Air-break disconnectors shall be installed between oil switches or circuit-breakers used as service switches and the supply wires.

f. Automatic overload circuit-breakers shall be located as near as possible to the point where the service wires enter the building, and shall be manually operable from a point which is readily accessible. 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 by trip-free breakers, by multipole breakers having an operating handle per pole or, for an air circuit-breaker, by a switch in series with each pole of the breaker. They shall indicate clearly whether they are open or closed.

g. 1. A suitable circuit-breaker or a switch and fuses shall be provided in the secondaries as required for low-voltage services in Section 130.4 of this code, except where the secondaries supply but one set of mains, in which case an automatic overcurrent circuit-breaker inserted in the primary mains and manually operable from a point outside of the vault or inclosure will be considered as sufficiently protecting and controlling the secondary mains, if the setting of the circuit-breaker is such as to afford overcurrent protection to the secondary conductors.

2. If the circuits leaving the transformer vault (which is owned by the user) are adequately protected either inside or outside the vault so they are manually operable under load from an accessible point outside the vault, the equipment in the vault may be protected with circuit breakers or fuses. The circuits leaving the vault are to be protected in

the manner specified in 1350.05 or according to Section 130.8.

The term "manually operable" in paragraphs f and g, preceding, calls for a mechanical, rather than electrical only, linkage between the circuit-breaker and the point of manual operation. A push-button type of electrical remote control may be used in addition thereto. The term "operable" assumes both the opening and the closing operations.

h. Fireproof transformer vaults should be located at the point of entrance of the service conductors into the building, or as near this point as practicable.

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

j. For services in hazardous locations, see Section 133.2 of this Code.

Order 1350.09. Grounding and Guarding.

a. All live parts, including conductors, which are connected to circuits of more than 600 volts between conductors shall be inclosed or isolated so as to be accessible to qualified persons only.

b. Except in stations and substations and in vaults under the sole control of the supply company, such inclosures if of metal and all noncurrent-carrying metal parts of fixed indoor equipment or apparatus shall be grounded as specified for equipment in Section 103 of this code.

c. Except in stations and substations and in vaults under the sole control of the supply company, the following distances of live parts above the level of the floor or other working surface shall be considered necessary to secure isolation by elevation.

Voltage Between Phases	Minimum Vertical Clearance of Unguarded Parts	
	Feet	Inches
600	7	8
2,300	7	9
6,600	7	10
11,000	9	0
22,000	9	3
33,000	9	6
44,000	9	10
66,000	10	5
88,000	11	0
110,000	11	7
132,000	12	2

d. Except in stations and substations and in vaults under the sole control of the supply company, adequate working space shall be provided about current-carrying parts upon which repairs or adjustments must be made while such parts are alive. The following table gives the least clear space which is permissible adjacent to such live parts when removable guards are taken away.

Voltage Between Phases	Minimum Horizontal Clearance of Unguarded Parts	
	Feet	Inches
600	3	2
2,300	3	3
6,600	3	4
11,000	3	6
22,000	3	9
33,000	4	0
44,000	4	4
66,000	4	11
88,000	5	6
110,000	6	1
132,000	6	8

e. Air-break disconnectors and fuses shall be accessible to qualified attendants only. Air-break disconnectors required by this section shall be arranged so that grounding connection on the load side can readily be made. Such grounding means need not be provided for duplicate disconnectors, if any, installed and maintained by the supply company.

f. Generator, switching, and motor rooms containing apparatus operated at more than 600 volts shall be securely locked except while a qualified operator is present.

Order 1350.10. Outdoor Substations.

a. Where step down transformers are located outdoors, the transformers, switches and other apparatus shall be so placed as not to interfere with firemen and not be accessible to unauthorized persons. They shall be adequately isolated with respect to combustibility, window exposure, and nature of occupancy of adjacent buildings. Unless isolated by elevation they shall be surrounded by a suitable inclosure, grounded if of metal, and placarded with a warning sign which indicates the highest voltage involved.

b. Drains for overflowing oil, if used, shall not expose buildings or combustible materials. When dikes, low walls or ditches are used to confine overflowing oil or to permit its escape without endangering adjacent buildings, the precautions as to adequate isolation specified in the preceding paragraph shall be observed.

SECTION 135.1. X-RAY AND HIGH-FREQUENCY APPARATUS

The requirements of this section shall be in addition to or amendatory of those prescribed in Sections 130.1 to 132.0, inclusive, of this code.

Order 1351.01. Barriers.

a. Adequate mechanical barriers shall be provided to prevent too close approach to any high-voltage parts of X-ray apparatus except X-ray tube and its leads. Such barriers may consist of grounded metal or of insulating material such as glass. High-voltage parts inclosed in a wooden cabinet shall have adequate spacing from the wooden walls. X-ray tubes used in therapy shall be mounted in a grounded metal inclosure.

It is recommended that all parts of high-voltage generators for X-ray tubes be inclosed in a separate room or cabinet arranged to have the supply circuit interrupted by a door switch.

b. If one side of the high-voltage circuit is grounded, the milliammeter shall be connected in the grounded lead, and need not be guarded. All operating parts such as spark-gap handles and regulating handles shall be made of suitable insulating material and shall be operative from outside of the barriers.

Order 1351.02. Wiring, Etc.

a. Overhead high-voltage stationary conductors shall be not less than seven feet six inches above the floor unless guarded from contact. The high-voltage leads on tilting tables and fluoroscopes shall be adequately insulated or so surrounded by barriers that inadvertent contact with them is improbable. Tube terminals and high-voltage wires connected thereto should be adequately insulated for a distance of 12 inches from the terminal. Shields for this purpose shall be designed to carry the high-voltage leads away from the patient in a direction at right-angles to the long axis of the tube.

b. The low-voltage circuit of a step-up transformer shall contain a manually operable circuit-breaker having no exposed live parts. There shall be an additional switch in this circuit, which for diagnostic work shall be one of the following types:

1. A switch with spring or other mechanism to open automatically except while held closed by the operator.

2. A time switch which will automatically open after a definite time for which it has been set.

It is recommended that any foot switch have a protective shield over the contact button, so as to avoid closure by accidentally stepping on it.

c. Where more than one piece of apparatus is operated from the same high-voltage source, each shall be provided with a high-voltage switch or equivalent disconnect means so as to give independent control.

d. Low-frequency current-carrying parts of machines of the quenched-gap or open-gap type shall be insulated or guarded so that they can not be touched during operation. This applies to all parts except the high-frequency circuit proper which delivers high-frequency current normally for therapeutic purposes.

e. Transformers which are a part of an X-ray or high-frequency apparatus, even though they contain oil, are to be considered and treated as a part of the device, and need not conform to the requirements of Order 1350.04 for power transformers.

Order 1351.03. Grounding, Etc.

a. Noncurrent-carrying metal parts of tube stands, fluoroscopes, and other apparatus shall be grounded in conformity with requirements of Section 103. Non-metallic tables and chairs are recommended. Tables of metal used for supporting patients shall be grounded if they are interposed between patient and X-ray tube or high-voltage leads; but shall be insulated from ground when the patient is supported between table and tube. Insulating floors, mats or platforms shall be provided for operators in proximity to high-voltage parts.

It is recommended that floors of concrete or other conducting material be completely covered with linoleum or other insulating material, lapped at the joints and without the use of metal for securing in place.

SECTION 136.0. SIGNAL SYSTEMS

The provisions of this section apply to electrical circuits for transmitting intelligence, including telephone, telegraph, district messenger, call bell and similar circuits.

Order 1360.01. Classification.

a. Signal systems come under four general classes, as follows:

Class 1. Signal systems used for protective purposes such as fire alarm, burglar alarm, etc. Systems of this class are also covered by appropriate codes for protective signaling systems.

For detailed service requirements for Fire Alarm, Sprinkler Supervisory or Watchman Systems, see Regulations of the National Board of Fire Underwriters.

Class 2. Systems in which the power is limited, as follows:

x. Circuits operated as a part of a central-station signaling system, such as telephone, telegraph, district messenger, and the like.

y. Local circuits (which may extend beyond one building) for signaling which meet any one of the following requirements:

1. Circuits operating at not exceeding 15 volts and fused at not more than five amperes. Where the current supply is from transformers or other devices having inherent current-limiting characteristics and approved for the purpose or from primary batteries, the fuse may be omitted.

2. Circuits operating at more than 15 volts but not exceeding 30 volts, and fused at not more than three amperes. Where the current supply is from transformers or other devices having inherent current-limiting characteristics and approved for the purpose or from primary batteries, the fuse may be omitted.

3. Circuits operating at more than 30 volts but not exceeding 60 volts, and fused at not more than 1⅓ amperes. Where the current supply is from a transformer or other device having inherent current-limiting characteristics and approved for the purpose, the fuse may be omitted. Where current-limiting means other than fuses are installed between the wiring and the source of supply which will limit the current at a fault to not exceeding one ampere, a three-ampere fuse may be used in place of the 1⅓ ampere fuse.

4. Circuits operating at more than 60 volts and fused at not more than one ampere, provided that such circuits are equipped with current-limiting means other than fuses which will limit the power as a result of a fault to not exceeding 150 watts.

Class 3. Signal systems of not more than 30 volts where the current is not limited as in Class 2.

Class 4. All other signal systems.

Order 1360.02. Installation.

a. The wiring methods and other installation details for Classes 1 and 2 signal systems shall comply with all of the provisions of Orders 1360.03 to 1360.06, inclusive, of this section.

b. The wiring methods and other installation details for Class 3 signal systems shall comply with the provisions of Orders 1360.03 to 1360.06, inclusive, of this section and in addition with the following:

1. The capacity of the power supply shall not exceed a rating of 1 K. W.

2. Wiring shall be installed in accordance with the methods described in Orders 1305.01 to 1305.16, inclusive, of Section 130.5 of this code. Branch-circuit conductors not individually fused (as allowed in sub-paragraph 5 below) shall be in conduit or other approved metallic raceways, in non-combustible raceways, or in cable approved for the purpose.

3. The number of wires in any conduit or other raceway need not be limited except that the combined cross-sectional area of all conductors shall not exceed 40 per cent of the cross-sectional area of the conduit or raceway.

4. Main or feeder conductors shall be protected in accordance with Section 130.8 of this code except that Nos. 18 or 16 conductors shall be considered as properly protected by 15-ampere fuses. Such No. 18 or 16 main or feeder conductors (Type RF–32) shall have their outer braid treated with a flame-retarding and moisture-resistant finish unless in metal or other non-combustible inclosure or raceway.

5. Branch-circuit conductors shall be not smaller than No. 18. Wires Nos. 18 and 16 shall have insulation at least equal to that of Type RF–32 rubber-covered fixture wire. For larger conductors standard Type R wire shall be used. Wires shall not carry currents in excess of those allowed in Column A of the table of Order 1306.12 of Section 130.6 of this code for the size of wire used, and need not be individually fused.

6. Main or feeder conductors shall not be in the same cable with branch-circuit conductors which are not individually fused, but may be in contact with the cable or placed under an additional covering inclosing both cable and main or feeder conductors.

c. The wiring methods and all installation details for Class 4 signal systems shall comply with the appropriate provisions of Sections 130.1–132.0, inclusive, of this code, except that limitations as to the number of outlets on a 15-ampere branch circuit may be waived.

Order 1360.03. Outside Wires.

a. Outside wires shall be placed underground or strung on poles. They shall not be run across or attached to roofs except by permission of the authority enforcing this code. This does not apply to small auxiliary buildings such as garages and the like.

b. Underground wires shall not be placed in a duct, handhole or manhole containing electric light or power wires. Where a handhole or a manhole is divided into sections by means of partitions of brick, concrete or tile, each compartment shall be considered as a separate handhole or manhole.

c. Overhead wires shall not be attached to a crossarm carrying electric light or power wires, nor shall they, when on the exterior walls of buildings, be brought closer than four inches to electric light or power wires, unless one system is in conduit or is permanently separated from the other system by a continuous and firmly fixed non-conductor, additional to the insulation on the wires.

d. The metal sheath of aerial cables which are liable to contact with electric light or power wires shall be grounded or shall be interrupted close to the entrance to a building by an insulating joint or equivalent device.

e. The distance between the two inside pins of any crossarm of a pole carrying signal and electric light and power wires shall be not less than 24 inches.

Note: It is recommended that signal wires, being smaller and more liable to break and fall, be placed on the lower crossarms.

f. Aerial cables of the metal-sheathed type may have paper or other suitable insulation. If the metal sheath is omitted each wire shall have $\frac{1}{32}$-inch rubber insulation and the bunched wires shall be covered with a substantial braid. Other kinds of cables not metal-sheathed may be used if approved for the purpose.

g. Wires from the last outdoor support to the protector, and wires attached to buildings shall have $\frac{1}{32}$-inch rubber insulation on each wire, and in addition the wires, either individually or bunched, shall be covered with a substantial braid. Where such wires are entirely within a block the insulation on each wire may be less than $\frac{1}{32}$ inch, but not less than 1/40 inch in thickness. Other kinds of wire approved

for the purpose may be used. Where not in conduit, such wires shall be separated from woodwork and supported on glass, porcelain or other insulating materials approved for the purpose.

h. Wires shall enter buildings either through non-combustible non-absorptive insulating bushings, or through approved rigid conduit. Conduit or bushings shall slope upward from the outside, or, where this cannot be done, drip loops shall be formed in the wires immediately outside the point of entrance. The conduit shall be equipped with an approved service head. More than one wire may enter through one conduit or bushing.

i. The preceding paragraphs g and h shall not apply where the wires enter a building in the form of a cable such as is described in paragraph f, of this section, nor where the entire street circuit is run underground, and the circuit within the block is so placed as to be free from chance of accidental contact with electric light or power wires of over 250 volts.

Order 1360.04. In Buildings; Generally.

a. Wires beyond the protector, or wires inside buildings where no protector is employed, shall be neatly arranged and secured in place in a convenient, workmanlike manner. They shall not approach nearer than two inches to any electric light or power wire unless one system is in conduit or the two systems are permanently separated by a continuous and firmly-fixed non-conductor, additional to the insulation on the wires.

Note: The wires would ordinarily be insulated, but the kind of insulation is not specified, as reliance is placed on the protector to stop all dangerous currents. Porcelain tubes or approved flexible tubing are considered suitable non-conductors.

b. Wires bunched together in a vertical run shall have a fire-resisting covering sufficient to prevent the carrying of fire from floor to floor. This requirement shall not apply if the wires are encased in non-combustible tubing, or are located in a fireproof shaft having firestops at each floor.

c. Signal wires and electric light and power wires may be run in the same shaft, if the two systems are separated at least two inches, or if either system is encased in non-combustible tubing.

d. Signal wires shall not be placed in a tube or compartment containing electric light or power wires, nor in the same outlet box, junction box or similar fitting or compartment unless separated from said electric light and power wires by a suitable partition, except where the power wires are introduced solely for power supply to signaling equipment or for connection to remote control equipment.

e. Transformers or other devices supplying current to signal systems from electric light or power circuits shall be of a type expressly approved for such service. The secondary wiring shall conform to the requirements of this section and the primary or the charging circuit wiring to the requirements of Sections 130.1 to 132.0, inclusive, of this Code. This transforming device shall be permitted only when the primary thereof is properly grounded as required in Section 103 of this Code.

Order 1360.05. In Buildings; Where the Distribution System Consists of Aerial Wires.

a. An approved protector shall be placed as near as practicable to the point of entrance to the building. The protector shall be mounted on a non-combustible, non-absorptive insulating base and shall consist of an arrester between each line wire and ground and a fuse in each line wire, the fuses protecting the arrester. The protector terminals shall be plainly marked to indicate "line", "instrument" and "ground".

Exception: The protector required may be located at the cable terminal pole from which the drop wires run to the building if the drop wires are free from liability to accidental contact with electric light or power lines of over 250 volts.

b. The protector shall not be placed in the immediate vicinity of easily ignitible material or flammable gases, or dust or flyings of combustible material.

c. Where the entire street circuit is run underground a protector shall not be required unless the circuit within the block is so placed as to be liable to accidental contact with electric light or power wires operating at a potential exceeding 250 volts.

The word "block" as used in these rules means a square or portion of a city, town or village inclosed by streets and includes the alleys so inclosed but not any street.

Order 1360.06. Grounding.

a. The grounding conductor of the protector shall consist of not less than No. 18 copper, having 1/32 inch rubber insulation, covered with a substantial braid. Where necessary, it shall be guarded from mechanical injury. If neces-

sary to guard the grounding conductor from mechanical injury (on poles or where a grounding conductor on the outside of building walls is near a roadway, sidewalk or pathway, thus necessarily exposing it to tampering by unauthorized persons) it shall be protected for a distance of 8 feet from the ground by a wooden moulding or by a conduit of nonmagnetic material.

b. The grounding conductor shall be run in as straight a line as possible to a permanent and effective ground. Where connection is made to a gas pipe, attachment shall be made between the meter and the street main. In every case the attachment shall be made as close to the earth as practicable.

A suitable ground may be obtained by connection to either a water or a gas piping system, preferably to the former. In the absence of such piping system a ground rod or pipe driven into permanently damp earth is acceptable.

c. The grounding conductor shall be attached to the pipe by means of an approved bolted clamp to which the conductor is soldered or otherwise connected in an approved manner.

d. Steam or hot-water pipes shall not be employed as a ground for protectors.

e. Fire and police alarm boxes.

1. Such signaling devices as fire and police alarm boxes and telegraph test boxes, if connected to overhead communication circuits exposed to lightning or to supply lines of more than 400 volts to ground, should have the accessible noncurrent-carrying metal parts permanently grounded where the character of service gives valid objection to the use of arresters or transformers on the signal circuit.

2. Police-alarm boxes, where connected to overhead police-alarm circuits, should be protected by arresters operating at 500 volts to ground, placed in the connecting leads outside the box.

3. Fire-alarm boxes connected to overhead circuits, if not protected by arresters, should be provided with suitable insulating material between the circuit within and the exposed frame and operating hook, this insulation to be capable of withstanding the highest voltage of the supply circuits to which the fire-alarm is exposed up to 7,500 volts.

Order 1360.07. Guarding Current-Carrying Parts.

a. Current-carrying parts.

Telephone or other communication devices which are permanently located outdoors or where exposed to corrosive fumes or dampness (such as may occur in subways, cellars, basements, laundries, stables, etc.) shall be so arranged that all ungrounded current-carrying parts are so guarded as to be suitably protected against the prevailing atmospheric conditions.

The inclosing cases of communication apparatus provide suitable guards if substantially built of metal or insulating materials.

b. Receiver cords.

Receiver cords shall be guarded by shields of permanently grounded metal (such as metal armor) or of non-absorptive insulating material (such as flexible insulating tubing), or shall have suitable insulating coverings for the individual conductors.

c. Shields for portable cords.

Where no protective device is installed (permissible only for fire-alarm or similar apparatus not for public use, where the character of service precludes the use of arresters and fuses) the shields of portable cords shall always be of grounded metal or of special insulating material suitable to withstand the voltage of the highest-voltage supply circuit to which the communication circuit is exposed up to 7,500 volts.

(d) Protective requirements for noncurrent-carrying parts. Where telephone or other communication apparatus (not included under (b) below) which must be handled by persons is permanently connected (not including portable telephones) to overhead communication circuits exposed to lightning or to supply lines of more than 400 volts to ground, provision against shock to persons handling apparatus shall be made by one or more of the following methods:

(1) The use of suitable protective devices, such as fuses and arresters, and for conditions of unusual exposure, drainage coils or transformers, or both.

(2) The grounding of all exposed noncurrent-carrying metal parts and the suitable guarding of all ungrounded current-carrying parts.

(3) The arrangement of apparatus in such a way that persons using it will be obliged to stand on a suitably insulated platform in a suitably insulated booth, or on other insulating surfaces. (The above applies only where apparatus is accessible to none but authorized persons.)

(4) The arrangement of apparatus (on communication circuits exposed to supply lines of more than 750 volts to

ground) so as to have no exposed current-carrying parts exceeding 2 square inches in area with which a person is liable to come in contact and the use of suitable protective devices, including fuses and arresters or other means.

Order 1360.08. Protection Against Induced Voltages.

All telephone or other communication equipment which must be handled by persons, and which is connected to a line that parallels a supply circuit in such manner that by reason of exposure to the supply circuit under normal conditions more than 150 volts are induced between the terminals of the communication equipment and ground, shall be protected by one or more of the following means:

(1) All exposed metal parts of the equipment shall be insulated from the circuit, and the circuit shall be protected by arresters having a break down potential not exceeding one-half that of the insulation between the above-named noncurrent-carrying metal parts and the current-carrying parts.

Cords shall have an additional insulating tubing protection.

(2) All exposed noncurrent-carrying metal parts shall be permanently grounded, and all current-carrying metal parts shall either be permanently grounded or adequately shielded.

(3) All equipment shall be so located that persons coming into contact with the equipment shall be obliged to stand either on an insulated platform or in a booth of suitable insulating material.

APPENDICES OF PART 3

Appendix G. Determining Required Size of Conduit

For combinations of wire not shown in Tables 1, 2 and 3 of Order 1305.03q the following method may be used to determine the proper size of conduit:

For a proper installation the combined cross sectional area of the conductors in a conduit may not exceed 40 per cent of the inside cross sectional area of the conduit. From Table 1 the area of any size wire may be obtained, and from Table 2 the area of any size conduit.

Example: Find size of conduit required to accommodate 2 No. 12 and 2 No. 10 A. W. G. wires.

Area of a No. 12 wire is .038 square inches

Area of a No. 10 wire is .049 square inches

Therefore $(2 \times .038) + (2 \times .049) = .174$ square inches.

From Table 2 it will be found that 40 per cent of the area of a one-half inch conduit is .122 square inches and hence would be too small. It would then be necessary to use a three-quarter inch conduit, although it is somewhat larger than absolutely necessary.

TABLE 1

Wires in Conduit, Dimensions of Rubber-Covered Wire

Wire	Area	Wire	Area	Wire	Area
14	.031	225,000 C.M.	.55	1,000,000 C.M.	1.74
12	.038	250,000 C.M.	.58	1,100,000 C.M.	2.04
10	.049	300,000 C.M.	.69	1,200,000 C.M.	2.16
8	.07	350,000 C.M.	.77	1,250,000 C.M.	2.22
6	.13	400,000 C.M.	.83	1,300,000 C.M.	2.27
5	.15	450,000 C.M.	.92	1,400,000 C.M.	2.40
4	.17	500,000 C.M.	.99	1,500,000 C.M.	2.52
3	.19	550,000 C.M.	1.11	1,600,000 C.M.	2.63
2	.21	600,000 C.M.	1.19	1,700,000 C.M.	2.78
1	.27	650,000 C.M.	1.27	1,750,000 C.M.	2.85
0	.31	700,000 C.M.	1.33	1,800,000 C.M.	2.89
00	.36	750,000 C.M.	1.39	1,900,000 C.M.	3.05
000	.42	800,000 C.M.	1.45	2,000,000 C.M.	3.14
0000	.49	850,000 C.M.	1.54		
		900,000 C.M.	1.60		
		950,000 C.M.	1.68		

TABLE 2

Dimensions of Conduit

Conduit	Area	40% of Area	Conduit	Area	40% of Area
½	.306	.122	3	7.34	2.93
¾	.516	.206	3½	9.94	3.97
1	.848	.339	4	12.7	5.08
1¼	1.49	.596	4½	15.9	6.36
1½	2.03	.812	5	19.9	7.96
2	3.32	1.328	6	28.8	11.52
2½	4.75	1.9			

Appendix H. Bare Conductors and Bus Bar Systems for Interior Wiring

a. A wiring installation of a nature coming under the scope of this section shall not be operated at more than 600 volts or for other than risers or feeders in buildings of fire-resistive construction only. These rules do not apply to central stations, substations, generator, transformer switching rooms, and other similar places used exclusively for electrical purposes, and accessible to qualified persons only.

b. Bare conductors or bus bars, installed in general spaces of buildings, shall be completely inclosed, so as to prevent accidental contact therewith.

c. Inclosures shall be of non-combustible material; they shall completely inclose the conductors, and may be of the grille type where used in spaces having no flammable materials stored, or handled, and where such spaces are inaccessible to other than qualified persons.

d. Where top covers are used to provide complete inclosure they shall be of sufficient strength to carry without collapsing any weights that might ordinarily be placed upon them.

e. Shall not be used in hazardous, extra hazardous or corrosive locations.

f. In troughs or shafts used exclusively for bare conductors or bus bars, openings shall be provided with non-combustible covers securely fastened or doors with suitable locks. Where the vertical shafts are of materially larger dimensions than are required to actually inclose the bare conductors, substantial guards shall be provided around the conductors which shall extend not less than 7 feet from the floor. Portions of fire-resistive walls forming these shafts which abut the run, may serve as a portion of the enclosure.

g. In shafts or troughs used for other electrical or mechanical purposes as well as for bare conductors or bus bars, they shall be inclosed from floor to ceiling, in no case shall other conductors or equipment be within the same inclosure that shields the bare conductors. Portions of fire-resistive inclosure may serve as portions of this inclosure as under Paragraph (f). If this inclosure is of grille type, all doors shall be provided with suitable locks.

h. Where a vertical shaft passes through a building floor, a non-combustible floor shall be placed in the shaft. Floor openings through which bare conductors or bus bars pass, shall be closed with fire-resistive plates. If of metal type, they shall have suitable insulating bushings extended at least six inches above plate. For alternating current, metal plates shall consist of non-magnetic materials. Where plates are composed of flat slabs of insulating materials, suitable insulating sleeves shall be placed around each conductor, extending upward therefrom at least six inches.

i. Insulating supports shall be composed of approved non-combustible, non-absorptive insulating materials, designed to provide adequate electrical spacing and mechanical strength for all conditions of service under which the system is to operate. Supports shall be carried on suitable hangers designed to meet the particular conditions of installation. On horizontal runs, fixed supports shall be provided at least every four feet. Where special conditions exist, the distance between fixed supports may be increased or decreased at the discretion of the Inspection Department, having jurisdiction, provided that intermediate spacing members embracing the entire group of conductors are used and spaced in accordance with the preceding. Vertical runs, having one fixed support at the top of same, shall be provided with intermediate spacing members, spaced not more than four feet apart for the balance of their length. Lateral supports shall be provided at least every 12 feet.

It is recommended that for horizontal runs, if the insulating material is notched to receive bus bars, that the insulating material completely encircle the conductor so as to prevent the accumulation of dirt on the surface of supports between bus bars. In cases where unusually high short circuit current may be anticipated special provision should be made as to spacing of conductors and strength and spacing supports.

j. Adequate provisions shall be made for expansion and contraction of horizontal and vertical buses. Care should be taken where runs turn at right angles to provide sufficient clearances between buses so that unequal expansion or contraction will not reduce the minimum spacings as given in the tables. Flexible links are recommended to provide for expansion of buses and shall be insulated with a flameproof covering where proper clearances cannot be provided. Flexible links shall have the same cross sectional area as the bare conductors to which they are attached and shall be rated as to current carrying capacity as though bare. Branch taps shall be so supported and arranged as to permit of movement of the main buses without putting undue stress on the branch tap connections.

k. Branch taps having a capacity for the load which they are to serve, may be connected without Automatic Overcurrent Protective Devices to bare conductors or bus bars regardless of the latter's size, provided that such taps do not extend beyond the shaft or inclosure, except that same may be carried to panel boards and the like, when mounted directly on the exterior of such shaft wall or inclosure.

The current ratings of these taps if of bare copper shall be as given herein, and if insulated, shall be in accordance with Table 1, Order 1306.12. Branch taps that are extended beyond shafts or inclosures, shall be installed in

accordance with portions of the Code which govern, and shall conform to its regulations for the type of wiring used. Branch taps not exceeding 25 feet to the nearest Automatic Overcurrent Protective Device, may be reduced in size to not less than one-fifth the rating of the fuse or circuit breaker setting protecting the bare conductors, and connected directly to the mains providing the load in amperes of the tap shall not exceed the current rating of the conductor as given in Table No. 1, Order 1306.12.

l. Where change in wiring is made from bare conductors or bus bars to other types of wiring, the capacity of connecting conductors used therefor, shall be as given in Table 1, Order 1306.12, according to the type of insulation used.

m. Where bare conductors or bus bars enter metal junction boxes, a suitable opening shall be made around each group of such conductors, and such openings covered with a slab of approved insulating material, not less than 1″ thick for slate, or ½″ for other approved composition insulating materials, or approved insulating bushings, passing through individual holes may be used if for direct current systems, but if for alternating current, all conductors of a circuit must pass through a common opening, except where nonmagnetic materials are used. Where these systems pass through walls of transformer vaults, switching rooms or through fire walls and the like, such openings shall be closed in a manner similar to that provided above. All bare conductors entering or passing through junction boxes shall be insulated and protected similar to the conductors contained therein.

n. For bare conductors or bus bars provided with ventilated inclosure, current rating of individual circuits carrying currents up to 1000 amperes, shall be based on 1200 amperes per square inch of cross section area, and where totally inclosed for their length on 1000 amperes per square inch of cross section area.

For circuits having a carrying capacity above 1000 amperes, special consideration shall be given to spacing and size of adjacent buses.

o. For individual circuits not exceeding 1000 amperes, minimum contact areas shall be provided as given in the following tables:

CLAMPED CONTACT SURFACES

Amperes in Circuit	100	200	400	600	800	1000
Amperes per square inch of contact area	250	245	240	230	220	210

BOLTED CONTACT SURFACES

Amperes in Circuit	100	200	400	600	800	1000
Amperes per square inch of contact area	200	190	180	170	155	140

For contact area of joints in round bars having threaded ends and joined by threaded couplings, the current densities given for clamped contact surfaces shall be used and the effective contact area shall be computed as follows:

Outside diameter of thread in inches times 2.25 times length of thread actually in contact with coupling shall equal square inches of contact area.

Where vertical runs of round bus bars are suspended from the top, consideration shall be given to the mechanical strength of the threads and couplings so that they may carry safely any weights imposed upon them.

Where currents per circuit exceed the maximum of 1000 amperes given in the tables, special consideration shall be given to the contact areas needed.

p. Spacing of nearest points of solid bus bars having opposite polarities or between nearest live point and ground, shall not be less than that given in the following table, based according to the voltage of the system on which they are to be used.

Voltage of Circuit	Distance Between Opposite Polarities In Air (Inches Minimum)	Distance Between Opposite Polarities On Surface (Inches Minimum)	Distance to Ground In Air (Inches Minimum)	Distance to Ground On Surface (Inches Minimum)
0–125	1.50	2.	1.50	2.
126–250	2.	3.	2.	3.
251–600	3.50	5.	3.50	5.

It is recommended that wider spacing be used wherever conditions will permit.

q. Bare conductors such as solid rod, tubing, flat bars, etc., shall not be used in less than 10 ft. lengths except where odd dimensions or physical conditions in the run make it necessary and it is recommended that lengths be longer in order to decrease the number of joints to a practical minimum.

r. All installations, including metal insulator supports, metal inclosures, and the like, together with cabinets and metallic raceways supplied from such systems, shall be grounded in accordance with Section 103. Bare copper strips having a cross section area equivalent to the wire sizes given in the above mentioned tables, are also acceptable for this type of construction.

PART 4

RULES TO BE OBSERVED IN THE OPERATION OF ELECTRICAL EQUIPMENT AND LINES

SECTION 140. SCOPE AND APPLICATION

Order 1400. Scope.

A. *Sections 141 to 143.* The safety rules in sections 141, 142, and 143 do not apply to new construction not yet energized, but apply to the operation of, or to work on or about, the following:

1. Supply lines.
2. Communication lines used in connection with supply lines.
3. Electrical equipment of central stations, substations, and private plants.
4. Electrical tests.
5. Electrical work in tunnel, subway, or similar underground structures.

B. *Sections 144 and 145.* The safety rules in these sections apply to commercial telephone and telegraph, and other communication equipment and lines, with terminology adapted to the special needs of the employees concerned. Communication equipment and lines include fire and police alarm systems, district messenger systems, and other communication systems not operated in connection with supply lines.

Order 1401. Application.

While all the rules find application in the larger industrial or private plants and in moderate-sized utilities, some do not apply, or apply less fully, in the smaller ones. It has seemed unwise, however, to attempt to restrict the scope of these rules to rules which are applicable to all organizations or to all classes of electrical work.

Order 1402. Exposed Communication Lines.

Communication equipment and lines are not considered alive, except where exposed to leakage or induction from

supply equipment or lines. They are, however, a source of danger when near live supply lines, due to their liability of being grounded.

SECTION 141. SUPPLY SYSTEMS—RULES FOR EMPLOYERS

Order 1410. General Requirements.

A. *Interpretation and Enforcement of Rules.* 1. Distribution. The employer shall furnish to each regular employee operating or working on electrical supply equipment, supply or communication lines, or hazardous electrical tests a copy of these safety rules for operation (or such of these rules as apply to his work), either separately or incorporated in more comprehensive rule books, and shall take means to secure the employee's compliance with the same.

Note: Many companies number their books of rules and require a receipt from each employee for his copy.

2. Interpretation. If a difference of opinion arises with regard to the meaning or application of these rules or as to the means necessary to carry them out, the decision of the employer or his authorized agent shall be final, unless an appeal is taken to the regulative body having jurisdiction.

3. Modification. Cases may arise where the strict enforcement of some particular rule will seriously impede the progress of the work in hand; in such cases the employee in charge of the work to be done may, with the consent of the chief operator concerned, make such temporary modification of the rule as will expedite the work without materially increasing the hazard.

B. *Organization Diagram.* An organization diagram or written statement clearly showing the division of responsibility between officials and employees, down to and including the grade of foreman, should be supplied with the book of rules, or the rules and organization diagram should be posted conspicuously in offices and stations of the employer and in other places where the number of employees and the nature of the work warrants.

C. *First-Aid Rules and Physicians' Addresses.* The rule book should contain or be accompanied by the following:

1. A list of names and addresses of those physicians and members of the organization who are to be called upon in emergencies.
2. A copy of rules for first aid, prone-pressure method of resuscitation and fire extinguishment. These should also

be kept in conspicuous locations in every station and testing room, in line wagons, and in other places where the number of employees and the nature of the work warrants.

D. *Instructing Employees.* Employees regularly working on or about equipment or lines shall be thoroughly instructed in methods of first aid, resuscitation by the prone-pressure method, and where advisable in fire extinguishment.

E. *Qualifications of Employees.* The employer shall use every reasonable means and precaution to assure himself that each employee is mentally and physically qualified to perform his work in accordance with these rules.

F. *Chief Operator.* 1. Authority. A properly qualified chief operator, system operator, load dispatcher, general superintendent, or otherwise designated employee shall be in charge of the operation of electrical equipment and lines and directly responsible for their safe operation. His duties shall be those prescribed in order 1421, A.

2. Deputy. In large organizations the duties of the chief operator may be delegated for any particular section of the system to a deputy chief operator (or otherwise designated employee) who shall report as required to the chief.

3. Large Organizations or Extended Systems. When it is impracticable to have the entire system placed in charge of one chief operator, the duties of the chief operator may be performed by a local superintendent, local manager, or other employee who may also perform other duties.

4. Small Organizations. The duties of the chief operator in small organizations may be performed for a portion of the system by a local superintendent, electrician, engineer, or some other employee who may also perform other duties.

Note: In these rules the various employees listed by above titles, including the deputy chief operator, will be designated (for simplicity) by the title of chief operator, where referred to in this capacity.

G. *Responsibility.* If more than one person is engaged in work on or about the same electrical equipment or lines at any one location, one of the persons shall be designated as the foreman locally in charge of the work; or, all of the workmen shall be instructed as to the work they are to perform, and the employee instructing the workmen shall be considered in charge of the work.

Order 1411. Protective Methods.

A. *Attendance.* Unless a qualified employee is kept on duty where generators or rotary converters are operating, such equipment shall be made inaccessible to unauthorized persons.

B. *Requirement for Two Workmen.* In wet weather or at night, at least two workmen should be assigned where the work is on or dangerously near live lines of more than 750 volts.

Exception: Trouble or emergency work is excepted.

C. *Unqualified Workmen and Visitors.* Unqualified employees or visitors shall be prohibited from approaching any live parts, unless accompanied by a qualified employee.

D. *Diagrams for Chief Operator.* Diagrams or equivalent devices, showing plainly the arrangement and location of the electrical equipment and lines, should be maintained on file or in sight of the chief operator.

Note: These diagrams may be of the entire system, or of each specific portion of the system, or they may show typical arrangements.

E. *Instructions to Employees.* All employees shall be instructed as to the character of all equipment or lines on or dangerously near to which work must be done by them. Instructions shall describe the equipment and lines to be worked on, identifying them either by position, letter, color, number, or name.

F. *Protective Devices.* A supply of suitable protective, first-aid, and fire extinguishing devices and equipment, sufficient to enable employees to meet the requirements of these rules, shall be provided in conspicuous and suitable places in electrical stations, testing departments, and line construction and repair wagons. The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case:

1. First-aid outfits.

2. Insulating wearing apparel, such as insulating gloves, sleeves, and boots. Insulating shields, covers, mats, stools, and platforms. Insulating appliances, such as rods and tongs, for any necessary handling or testing of live equipment or lines.

3. Protective goggles of suitable materials and construction.

4. Tools of such special design and insulation as to eliminate so far as practicable the danger of forming short-circuits across conducting parts at different potentials or bringing the user into circuit with such parts.

5. "Men at work" or equivalent tags, log books, operation diagrams, or equivalent devices, and portable danger signs.

6. Fire-extinguishing devices, for safe use on live parts.

7. Grounding devices for making protective grounds.

G. *Inspection of Protective Devices.* Such devices and equipment shall be inspected or tested to insure that they are kept in good order. Safety belts, whether furnished by employer or employee, should be inspected periodically to assure that they are in safe working condition.

H. *Warning Signs.* Permanent warning signs forbidding entrance to unauthorized persons shall be displayed in conspicuous places at all unattended and unlocked entrances to electrical supply stations, substations, and testing rooms containing exposed current-carrying parts or moving parts.

I. *Danger Signs.* Suitable danger signs shall be placed in supply stations, substations, switching towers, and testing rooms about equipment having exposed current-carrying parts of more than 750 volts.

SECTION 142. SUPPLY SYSTEMS—GENERAL RULES FOR ALL EMPLOYEES

Order 1420. General Precautions.

A. *Rules and Emergency Methods.* The safety rules should be carefully read and studied.

Employees may be called upon at any time to show their knowledge of the rules.

Employees should familiarize themselves with approved methods of first-aid, resuscitation, and fire extinguishment.

B. *Heeding Warnings, Warning Others.* Employees whose duties do not require them to approach or handle electrical equipment and lines should keep away from such equipment or lines. They should cultivate the habit of being cautious, heeding warning signs and signals, and always warning others when seen in danger near live equipment or lines.

C. *Inexperienced or Unfit Employees.* No employee shall do work for which he is not properly qualified on or about live equipment or lines.

Exception: Work done under the direct supervision of an experienced and properly qualified person is excepted.

D. *Supervision of Workmen.* Workmen, whose employment incidentally brings them in the vicinity of electrical supply equipment or lines with the dangers of which they are not familiar, shall proceed with their work only when authorized. They shall then be accompanied by a properly qualified and authorized person, whose instructions shall be strictly obeyed.

E. *Exercising Care.* Employees about live equipment and lines should consider the effect of each act and do nothing which may endanger themselves or others. Employees should be careful always to place themselves in a safe and secure position and to avoid slipping, stumbling, or moving backward against live parts. The care exercised by others should not be relied upon for protection.

F. *Live and Arcing Parts.* 1. Treat Everything as Alive. Electrical equipment and lines should always be considered as alive, unless they are positively known to be dead. Before starting to work, preliminary inspection or test should always be made to determine what conditions exist. (See order 1422, A, for general requirements and order 1424, C, for test of circuit).

2. Protection Against Arcs. The hands should be covered by protecting and insulating gloves and the eyes by suitable goggles or other means if exposed to injurious arcing. Either a thin rubber glove used with a protective outer glove or a heavier rubber glove used alone shall be considered as both protecting and insulating.

Employees should keep all parts of their bodies as far away as possible from brushes, commutators, switches, circuit-breakers, or other parts at which arcing is liable to occur during operation or handling.

G. *Safety Appliances.* Employees at work on or near live parts should use the protective devices and the special tools provided. Before starting work these devices or tools should be examined to make sure that they are suitable and in good condition.

Note: Protective devices may get out of order or be unsuited to the work in hand.

H. *Suitable Clothing.* Employees should wear suitable clothing while working on or about live equipment and lines. In particular, they should keep sleeves down and avoid wearing unnecessary metal or flammable articles, such as rings, watch or key chains, or metal cap visors, celluloid collars, or celluloid cap visors. Loose clothing and shoes that slip easily should not be worn near moving parts.

I. *Safe Supports.* Employees should not support themselves on any portion of a tree, pole structure, scaffold, lad-

der, or other elevated structure without first making sure that the support is strong enough. Supports should be reinforced if necessary.

Conducting paint should not be used in painting portable ladders. Portable ladders should not be reinforced longitudinally with metal when used in electrical stations.

Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the supporting surfaces are smooth or vibrating.

J. *Safety Belts.* Employees working in elevated positions should use a suitable safety belt or other adequate means to guard against falling. Before an employee trusts his weight to the belt, he should determine that the snaps or fastenings are properly engaged and that he is secure in his belt. Any employee who furnishes his own belt shall from time to time submit it to his employer for inspection.

K. *Fire Extinguishers.* Employees should avoid using fire-extinguishing liquids which are not insulating in fighting fires near exposed live parts. If necessary to use them, all neighboring equipment should first be killed.

L. *Repeating Messages.* Each person receiving an unwritten message concerning the handling of lines and equipment shall immediately repeat it back to the sender and secure his full name or other identification and acknowledgment. Each person sending an unwritten message shall require it to be repeated back to him by the receiver and secure the latter's full name.

Order 1421. Operating Routines.

A. *Duties of Chief Operator.* The chief operator, described in order 1410, F, shall—

1. Keep informed of all conditions affecting the safe and reliable operation of the system.

2. Keep a suitable record or log book showing all changes in such conditions. He shall read and sign such record when assuming duty and sign again on being relieved.

3. Keep within sight operating diagrams or equivalent devices indicating whether electrical supply circuits are open or closed at stations under his immediate jurisdiction, and where work is being done under his special authorization.

Exception: These indicating devices shall not be required for any chief operators classed under paragraphs 3 and 4 of order 1410, F, if the record or log sheets show all conditions affecting the safe and reliable operation of the system.

Note: In these rules the person performing these duties is designated as chief operator, regardless of his ordinary title.

B. *Duties of Foreman.* Each foreman in charge of work shall adopt such precautions as are within his power to prevent accidents and to see that the safety rules are observed by the employees under his direction. He shall make all the necessary records, and shall report to his chief operator when required. He shall, as far as possible, prevent unauthorized persons from approaching places where work is being done. He shall also prohibit the use of any tools or devices unsuited to the work in hand or which are so defective or in such poor condition as to make them unsafe.

C. *Qualified Guides.* The qualified persons accompanying uninstructed workmen or visitors near electrical equipment or lines shall take precautions to provide suitable safeguards and see that the safety rules are observed.

D. *Special Authorization.* 1. Special Work. Special authorization from the chief operator shall be secured before work is begun on or about station equipment, transmission, or interconnected feeder lines or live lines of more than 7,500 volts, and in all cases where lines are to be killed by regular procedure at stations, and a report shall be made to him when such work ceases.

Exceptions: In emergency, to protect life or property, or when communication with the chief operator is difficult, due to storms or other causes, any qualified employee may make repairs on or about the equipment or lines covered by this rule without special authorization if the trouble is such as he can promptly clear with help available in compliance with the remaining rules. The chief operator shall thereafter be notified as soon as possible of the action taken. (See order 1421, H, 2, for crossed or fallen wires.)

2. Operations at Stations. In the absence of specific operating schedules for opening and closing supply circuits at stations, or starting and stopping equipment, employees shall secure special authorization from the chief operator before performing these operations. In all cases such special authorization shall be secured where circuit or equipment control devices are tagged at stations to protect workmen. (See order 1421, F, for tagging electrical circuits).

Exceptions: In emergency, to protect life or property, any qualified employee may open circuits and stop moving equipment without special authorization if, in his judgment, his action will promote safety, but the chief operator shall be notified as soon as possible of such action, with reasons therefor. To maintain service, any quali-

fied employee may also reclose circuits which have been opened by fuses or automatic circuit-breakers except where this is prohibited by rule.

3. Cutting out Sections of Circuits. Special authorization shall be secured from the chief operator before sections of overhead or underground circuits are cut off by employees at points other than at stations by means of sectionalizing switches.

Exception: Portions of distribution circuits of less than 7,500 volts may be cut off by authorized employees without special authorization from the chief operator, by means of sectionalizing switches, if the chief operator is thereafter notified as soon as possible of the action taken. This may also be done even for circuits of more than 7,500 volts when communication with the chief operator is difficult.

E. *Restoring Service After Work.* No instructions for making alive equipment or lines which have been killed by permission of the chief operator to protect workmen shall be issued by him until all workmen concerned have been reported clear. When there is more than one workman at a location, a person authorized for the purpose shall report clear for such workmen, but only after all have reported clear to him. If there is more than one gang, each shall be so reported clear to the chief operator.

F. *Tagging Electrical Supply Circuits.* 1. When Tags are Placed at Direction of Chief Operator. Before work is done at direction of chief operator on or about equipment or circuits, under any of the following conditions, the chief operator shall have "Men at work" or equivalent tags attached at all points, where such equipment or circuits can be manually controlled by regular operators. The tags should be placed to plainly identify the equipment or circuits worked on.

(a) Transmission or interconnected feeder circuits.

(b) Circuits operating at more than 7,500 volts.

(c) Circuits killed at stations and substations to protect workmen.

2. When tags are Placed at Direction of Authorized Employees. Before work is done on or about any equipment or lines which are killed by authorized employees at points other than at stations, the employees shall have "Men at work" or equivalent tags placed at all points where the circuit has been disconnected to identify the portion worked on.

G. *Maintaining Service.* 1. Closing Tagged Circuits which have Opened Automatically. When live circuits on which "Men at work" or equivalent tags have been placed have opened automatically, they should be kept disconnected until the chief operator has given proper authorization for reconnection.

2. Closing Circuits Operated Automatically. When overhead circuits, other than trolley and third-rail circuits, open automatically, the employer's local operating rules shall determine in what manner and how many times they may be closed with safety for persons on or near those circuits. The chief operator shall be advised of the conditions.

3. Grounded Circuits. When circuits feeding supply lines become accidentally grounded, they shall be tested to determine where the ground exists. If the ground can not be definitely located and removed by the station operator, an immediate report of the finding shall be given to the chief operator, who shall order a patrol of the lines affected to definitely locate and remove the ground as soon as practicable.

Note: On circuits exceeding 7,500 volts, it will usually be found advisable to disconnect the circuit or effectively ground the accidentally grounded conductor until the lines have been cleared of the accidental ground.

H. *Protecting Traffic.* 1. Barrier Guards. Employees shall first erect suitable barrier guards before engaging in such work as may endanger traffic. They shall also display danger signs or red lamps placed so as to be visible to traffic approaching from any direction. A man shall be stationed to warn passers-by while work is going on where the nature of work and traffic requires it.

2. Crossed or Fallen Wires. An employee finding any crossed or fallen wires which may create a hazard shall remain on guard or adopt other adequate means to prevent accidents, and shall have the chief operator notified. If the employee can observe the rules for handling live parts by the use of insulating appliances, he may correct the condition at once; otherwise he shall first secure the authorization from the chief operator for so doing. (See order 1421, D, for special authorization).

I. *Protecting Workmen by Switches and Disconnectors.* When equipment or lines are to be disconnected from any source of electrical energy, for the protection of workmen, the operator shall first open the switches or circuit-breakers designed for operation under load, and then the air-break disconnectors, when provided.

Order 1422. Handling Live Equipment or Lines.

A. *General Requirements.* 1. Touching Live Parts. An employee should never touch with bare hands two parts at different potential at the same time. He should never touch with bare hands even a single exposed ungrounded live part at a dangerous potential to ground unless he is insulated from other conducting surfaces, including the ground itself, and stands on insulating surfaces.

2. Wire Insulation. Employees should not place dependence for their safety on the insulating covering of wires.

All precautions in this section for handling live parts shall be observed in handling insulated wires.

Note: Insulation on a wire may look perfect, but it frequently will not prevent shock.

3. Exposure to Higher Voltages. Every employee working on or about equipment or lines exposed in overhead construction to voltages higher than those guarded against by the safety appliances provided should as far as practicable assure himself that the equipment or lines worked on are free from dangerous leakage or induction or have been effectively grounded.

4. Cutting into Insulating Coverings of Live Conductors. When the insulating covering on live wires or cable must be cut into, the employee should use a suitable tool.

Recommendation: While doing such work, it is recommended that suitable goggles be worn to protect the eyes, and insulating gloves to protect the hands.

When metal sheathing must be removed from cables, it should be done with special tools which will not injure the insulation. The sheathing should be cut so as to leave enough exposed insulation after the conductor has been bared to avoid arcing over between the conductor and the sheath. If the cable consists of more than one conductor, similar exposed insulating surface should be left for each conductor, using insulating separators between conductors, if necessary.

Insulating devices, such as wood separators, etc., should be examined, and conducting dust or chips, sharp edges, or nails should be eliminated to avoid defeating the purpose for which the devices are intended.

5. Metal Tapes or Ropes. Metal measuring tapes, and tapes, ropes, or hand lines having metal threads woven into the fabric should not be used near exposed live parts.

6. Metal Reinforced Ladders. Ladders reinforced by metal in a longitudinal direction should not be used near exposed live parts.

B. *Avoiding Shock-Voltages Between 750 and 7,500.* No employee should go, or take any conducting object without a suitable insulating handle, within 6 inches of any exposed live part whose voltage exceeds 750, where it is practicable to avoid this. Where safe distance from live parts can not be secured by use of the special insulating tools and appliances furnished, properly tested insulating gloves and sleeves may serve as the sole portable insulating devices between the person and live parts.

Exception 1: In dry locations this distance may be less than 6 inches, if insulating devices, such as shields, covers, or gloves are placed between the person and the part or object.

Exception 2: In dry locations, the distance may also be reduced if insulating barriers (such as mats, stools, or platforms) are placed between the person and the ground, and suitable insulating shields between the person and all other conducting or grounded surfaces, which he could accidentally touch at the same time.

Exception 3: In all damp or dark locations, the distance may be less than 6 inches only if insulating devices are used between the person and the live parts and also between him and all other conducting surfaces with which he might otherwise come in contact at the same time.

Note: Care should be exercised in using insulating gloves to avoid puncturing them on sharp edges, especially in making wire splices. It is generally advisable to wear protecting gloves over insulating gloves.

C. *Avoiding Shock-Voltages Exceeding 7,500.* 1. Clearances from Live Parts. No employee should go, or take any conducting object, within the distances named below from any exposed live part at or above the voltage specified.

CLEARANCE FROM LIVE PARTS

Operating voltage.	Distance in Feet
7,500	1
15,000	2
50,000	3
70,000	5

Distances for intermediate voltages to be determined by interpolation.

Exception: In dry locations these distances may be reduced if suitable insulating guards or barriers are placed between the person and such part or object.

2. Guards. If the part is being directly worked on, the tools or other mechanical appliances used shall have insulat-

ing handles of sufficient length to permit the operator to maintain the distance specified in order 1422, C, 1 preceding.

Exception: This does not apply if protective guards are also used between the person and the live part.

Note: These protective guards may be permanent insulating covers or shields, or may be disks of insulating material, suitable for the voltages to be handled and for the attendant conditions, attached to the handles of rods or tools.

D. *Requirement for Two Workmen.* In wet weather or at night no employee shall work alone on or dangerously near live lines of more than 750 volts.

Exception: Trouble and emergency work is excepted.

E. *When to Kill Parts.* An employee shall not approach, or willingly permit others to approach, any exposed ungrounded part normally alive closer than permitted by order 1422, A, B, or C, unless the supply equipment or lines are killed.

Note: This is to ensure the employee of his own safety and the safety of those working under his direction.

F. *Opening and Closing Switches.* Manual switches and disconnectors should always be closed by a single unhesitating motion, and, if possible, with one hand. Care should be exercised in opening switches to avoid causing serious arcing.

G. *Work from Below.* Employees should avoid working on equipment or lines from any position by reason of which a shock or slip will tend to bring the body toward exposed live parts. Work should, therefore, generally be done from below, rather than from above.

H. *Attaching Connecting Wires and Grounds.* 1. Handling Connecting Lines. In connecting dead equipment or lines to a live circuit by means of a connecting wire or device, employees should first attach the wire to the dead part before attaching it to the circuit. When disconnecting, the live end should be removed first. Loose conductors shall be kept away from exposed live parts.

2. Applying Grounds. On applying a grounding device to normally live parts, the device shall be grounded before being brought near the parts and shall be removed from the live parts before being removed from the ground connection.

I. *Handling Series Circuits.* Secondaries of current transformers to meters or other devices should not be

opened when alive until a jumper has been connected across the point of opening or the circuit has been short-circuited elsewhere.

Before working on arc lights connected to series circuits, they shall be short-circuited or (when necessary to avoid hazard) disconnected entirely from such circuits by absolute cutouts.

J. *Stringing Wires.* In stringing wires near live conductors, they should be treated as alive unless they are effectively grounded.

Order 1423. Killing Equipment or Lines.

A. *Application of Rule.* Where workmen must depend on others for operating switches to kill circuits on which they are to work, or must secure special authorization from the chief operator before themselves operating such switches, the following precautionary measures shall be taken in the order given, before work is begun on or about the equipment or lines concerned, as a means for preventing misunderstanding and accident.

In small organizations the chief operator may himself operate the switches and disconnectors instead of instructing others to do so, thus much simplifying and abbreviating the procedure. In certain cases the chief operator may direct the workman who wishes the section killed for his own protection to operate some or all switches necessary himself, thus also abbreviating the procedure.

In cases where there is no station with regular attendants at either end of a section of line to be killed for the protection of workers, the rules below need not apply for disconnection of that end of the section concerned, provided that the employee under whose direction that end of the section is disconnected is in sole charge of the section and of the means of disconnection employed or that the point of disconnection at that end of the section is suitably tagged before work proceeds.

B. *Workman's Request.* The workman in charge of the work shall apply to the chief operator to have the particular section of equipment or lines killed, identifying it by position, letter, color, number, or other means.

C. *Opening Disconnectors and Tagging.* The chief operator at his discretion shall direct the proper persons to open all switches and air-break disconnectors through which electrical energy may be supplied to the particular section of equipment and lines to be killed, and shall direct

that such switches and disconnectors be tagged with a tag of a distinctive character indicating that men are at work. All oil switches and remotely controlled switches should also be blocked where necessary for avoiding mistakes.

A record shall be made when placing the tag giving the time of disconnection, the name of the man making the disconnection and the name of the workman who requested the disconnection, and the name of the chief operator.

Where the section of equipment or lines can be made alive from two or more sources, all such sources shall be disconnected.

Note: This will apply to work on lines with more than one station, also sometimes to work on transformers in banks, rotary converters, motor generators, switches, and other similar equipment.

D. *Station Protective Grounds.* When all the switches and disconnectors designated have been opened, blocked, and tagged in accordance with order 1423, C, the chief operator shall require that protective grounds be made upon the lines which have been killed and that they are reported to him when placed.

Exception: This requirement does not apply under conditions where the making of such grounds will itself be more hazardous than working on lines without grounding.

E. *Permission to Work.* Upon receipt of information from all persons operating switches and disconnectors that protective grounds are in place, the chief operator shall advise the workman who requested the killing of the section that the specified section of equipment or line has been killed and that he may proceed to work.

F. *Workmen's Protective Grounds for Overhead Lines.* The workman in charge should immediately proceed to make his own protective grounds on the disconnected lines, except under conditions where the making of such grounds will itself be more hazardous than working on the lines without grounding. Such grounds shall be made between the particular point at which work is to be done and every source of energy.

G. *Proceeding with Work.* After the equipment or lines have been killed (and grounded, if required by F above), the workman in charge and those under his direction may proceed with work on the grounded or killed parts. Care, however, shall be taken to guard against adjacent live lines or parts.

H. *Procedure for Other Gangs.* Each additional workman in charge desiring the same equipment or lines to be killed for the protection of himself or the men under his direction shall follow the same procedure as the first workman and secure similar protection.

I. *Reporting Clear-Transferring Responsibility.* The workman in charge, upon completion of his work, and after assuring himself that all men under his direction are in safe positions, shall remove his protective grounds and shall report to the chief operator that all tags protecting him may be removed, and shall give his location and report as follows: "Mr. ---------- and men clear and all grounds removed".

The workman in charge who received the permission to work may transfer this permission and the responsibility for men under him, as follows:

He shall personally inform the chief operator of the proposed transfer, and if this is permitted, the name of the successor shall be entered at that time on the tags concerned or in the records of the persons placing the tags and of the chief operator. Thereafter the successor shall report clear and shall be responsible for the safety of the original workmen, so far as this is affected by the removal of tags.

J. *Removal of Tags.* The chief operator shall then direct the removal of tags for that workman and the removal shall be reported back to him immediately by the persons removing them. Upon the removal of any tag, there shall be added to the record the name of the chief operator and workman who requested the tag, the time of removal, and the signature of the person removing the tag.

K. *Restoring Service.* Only after all protecting tags have been removed by the above procedure from all points of disconnection shall the chief operator, at his discretion, direct the removal of protective grounds and blocks and the closing of any or all disconnectors and switches.

Order 1424. Making Protective Grounds.

A. *Application of Rule.* When making temporary protective grounds on a normally live circuit, the following precautionary measures shall be observed in the order given, and the ground shall be made to all wires of the circuit which are to be considered as grounded.

B. *Ground Connections.* The employee making a protective ground on equipment or lines shall first connect one

end of grounding device to an effective ground connection supplied for the purpose.

C. *Test of Circuit.* The normally live parts which are to be grounded should next be tested for any indication of voltage, the employee carefully keeping all portions of his body at the distance required from such parts when alive by the use of suitable insulating rods or handles of proper length, or other suitable devices.

D. *Completing Grounds.* If the test shows no voltage, or the local operating rules so direct, the free end of the grounding device shall next be brought into contact with the normally live part and securely clamped or otherwise secured thereto before the employee comes within the distances from the normally live parts specified in order 1422, B and C, or proceeds to work upon the parts as upon a grounded part.

In stations, remote-control switches can sometimes be employed to connect the equipment or lines being grounded to the actual ground connection. On lines it is generally necessary to resort to portable grounding devices handled directly by means of insulating handles, rods, or ropes.

E. *Removing Grounds.* In removing a protective ground the employee shall not remove the grounding device from the ground connection until the device has been disconnected from all normally live current-carrying parts.

SECTION 143. SUPPLY SYSTEMS—RULES FOR EMPLOYEES DOING SPECIALIZED WORK

Order 1430. Supply Stations and Switchboards.

A. *Application of Rule.* Engineers, machine attendants, switchboard operators, and helpers shall study and strictly observe the following, in addition to all the general orders 1420 to 1424 which apply to their work.

B. *Care About Machines.* Do not allow oil cans, tools, dusters, or wiping cloths to catch in moving parts of machinery. In passing any switchboard or machine in operation, do not touch it unnecessarily nor allow metal tools or other metal objects to touch the apparatus or connections. Do not use iron or tin oil cans near field magnets, and use only dusters and wipers with insulating handles on or about exposed live parts. Employees about to work on normally moving parts of remotely controlled equipment during periods of rest, shall be protected against their accidental starting by "Men at work" or equivalent signs first being

placed on the starting devices, and by locking or blocking these where practicable. All employees shall, before starting any work, satisfy themselves that all these protective devices have first been installed. (See order 1423).

C. *Care About Live or Moving Parts.* Do not work on or near exposed live or moving parts unless authorized to do such work, and then strictly observe the rules applying.

When working near fuses and circuit breakers or other apparatus which may arc suddenly, be careful to avoid injury from their operation.

When working on one section of a switchboard or in one compartment, mark it conspicuously and place barriers to prevent your accidental contact with live parts in that section or adjacent sections.

When working on or about live parts and standing on insulated stools or ladders, or when otherwise insulated from the ground, avoid handing metal tools or other objects to other persons who are not insulated.

D. *Handling Fuses or Brushes.* In handling fuses of more than 750 volts, use the special rods or tongs and stand on insulating platforms or mats, where provided. Keep the body as distant and as far below as possible.

Replace or remove link fuses from live terminals and handle brushes on live equipment only when absolutely necessary, and then with due precautions.

E. *Battery Rooms.* Do not smoke or cause arcing in storage-battery rooms. The use of open flames should be avoided, especially while the cells are gasing and should be permitted only in special cases under the direct supervision of an experienced person and after the room has been thoroughly ventilated.

Do not handle live parts of batteries or their connections unless standing on insulating platforms or wearing suitable insulating boots.

F. *Working in Elevated Positions.* When working in an elevated position, especially above live or moving parts, assure yourself of the security of your position and support, and take precautions to avoid dropping tools or materials.

G. *Handling Switchboard Equipment.* All ungrounded metal parts of devices on switchboards shall be handled as if operating at the highest voltage to which any portion of the equipment on the same switchboard panel is subject, unless the parts are known, by test or otherwise, to be free from such voltage.

When cable plug connectors are used, do not allow one

end to remain hanging loose while the other end is connected to a live terminal.

In handling instrument circuits, the secondary of a current transformer should never be opened when it is alive.

H. *Reporting Circuit Trouble to Chief Operator.* Report to your immediate superior or to the chief operator any unusual conditions of load and the indication of any accidental ground on an outgoing circuit.

I. *Reporting Defects.* Promptly report to your superior any dangerous conditions of equipment or surroundings, including defective tools, switches, or protective devices, or live cases or frames of apparatus or instruments.

Order 1431. Meters.

A. *Application of Rule.* All meter setters and testers shall study and strictly observe the following in addition to all the general orders in 1420 to 1424 which apply to their work.

B. *Taped Joints.* Never leave joints or loose ends of wires untaped unless otherwise protected.

C. *Care About Live Parts.* Do not use bare fingers or hands to determine whether a circuit is alive. Never remove or replace fuses in live circuits of more than 750 volts except by means of the suitable appliances provided.

D. *Opening Circuits at Switches.* Special care should be exercised in opening circuits at meter connections unless the circuits have been first properly opened at switches.

E. *Current-Transformer Secondaries.* Before working on an instrument or other device in a current-transformer secondary circuit, always bridge the device with jumpers, so that the circuit can not be opened at the device. Never open such a circuit at meter connections until it has been elsewhere bridged.

F. *Special Tools.* Use only hand tools suited to the work in hand and so reduce the danger of short-circuits.

G. *Reporting Defects.* Promptly report to your immediate superior any live meter case or any condition of a meter or its connections, of the interior wiring or of overhead lines, of your own or other utilities, which might endanger life and property.

Order 1432. Testing.

A. *Application of Rule.* All electrical testers, helpers, and others working about electrical tests shall study and strictly observe the following, in addition to all the general

orders in 1420 to 1424. Owing to the diversified character of testing work this study should usually extend also to the special rules in 1433 to 1435.

B. *Authorization of Work.* Do not work on or about equipment or lines without first receiving authorization from the person in charge.

Note: If such equipment or lines are under control of a chief operator, this authorization must come from him. This will include the attaching of tags at the proper points and the observation of all rules for general operation in 1421.

C. *Checking of Conditions.* Thoroughly familiarize yourself with all conditions surrounding equipment or lines to be tested before making any change in these conditions.

Do not make any change in equipment or lines unless you fully understand the effect of the change.

D. *Foreman.* One properly qualified person shall be in immediate charge of all testing work, or all of the workmen shall be instructed as to the work they are to perform and the employee instructing them shall be considered in charge of the work.

E. *Warnings and Barriers.* Display danger signs and erect suitable guards about all equipment or lines under test when in places where traffic is frequent, if live or moving parts would otherwise be exposed.

When temporary wiring, belts, pulleys, or other temporary live or moving parts must be guarded, suitable portable or temporary guards and warning signs shall be used.

F. *Requirement for Two Workmen.* No person should work alone in testing or experimental work on or about parts on which the voltage can exceed 750 volts, except in routine testing where the live parts are properly guarded.

G. *Reporting Defects.* Promptly report to your immediate superior any conditions of equipment or lines under test which may endanger life or property.

Order 1433. Overhead Lines.

A. *Application of Rule.* Linemen and assistants and groundmen, in construction, extension, removal, or repair work, shall study and strictly observe the following, as well as all the general orders in 1420 to 1424 which apply to their work.

B. *Testing Structures Before Climbing.* Before climbing poles, ladders, scaffolds, or other elevated structures, first assure yourself that the pole, ladder, scaffold, tree, cross arm, messenger wire, cable car, or boatswain's chair,

or other elevated support, is strong enough to safely sustain your weight.

Note: Poles may be tested for decay near the ground line with a bar, screw driver, or other tool, and sounded for decay at the center by rapping with a heavy tool or block of wood.

When poles or cross arms are apparently unsafe because of decay or unbalanced tensions of wires on them, they should be properly braced or guyed before they are climbed.

C. *Use of Pole Steps.* When poles are stepped, make use of such steps in climbing.

D. *Unsafe Supports.* Do not support yourself by pins, brackets, or conductors.

E. *Spurs.* Spurs with gaffs worn short shall not be used. The gaffs on spurs shall be kept sharp, and spurs shall fit properly. Spurs shall not be worn on work for which they are not required, nor while men are traveling to or from work.

F. *Care About Live Parts.* 1. Do not go among any wires until you know their voltage.

2. Leaning over and crowding through unprotected wires should be avoided wherever possible.

3. Place yourself so that you will not be liable to fall on wires should an accident occur.

4. Do not depend on the insulating covering of wires, and treat all lines as alive unless they have been properly killed (except communication lines known to be clear).

5. Avoid use of hand lines or measuring tapes containing metal strands.

6. In handling dangerous switches or fuses, do so only by means of suitable insulating handles, rods, or tongs.

G. *When Touching Live Parts.* When working on live equipment or wires never allow any portion of the body to come in contact with any live or grounded part other than that worked on.

While touching supply wires or equipment, avoid as far as possible touching ground wires, guy wires, span wires, metal pipes, metal poles, metal sheaths, communication wires or equipment, transformer cases, hangers, and other metal fixtures.

Note: Communication wires are included principally because of their liability of being grounded. The other equipment and wires listed may become either alive or grounded.

While touching communication wires or equipment, metal sheaths, metal pipes, ground wires, or metal fixtures on poles, avoid as far as possible touching supply wires or equipment, guy or span wires.

H. *Protecting Traffic.* When working overhead, keep tools and materials not in use in proper receptacles; tools or materials should not be thrown to or from the man on the pole, but should be raised or lowered by means of a hand line, using proper receptacles where practicable. Pole holes and obstructions along public highways and other frequented places shall be protected by watchmen or by suitable guards or danger signals so located as to be conspicuous to traffic.

When working overhead, or hoisting or lowering materials above places where frequent traffic occurs, a man should be stationed to warn passers-by.

Note: Where traffic is light, warning signs or barriers may be used in lieu of watchmen. Where traffic is congested, it may be necessary to rope off the space.

I. *Avoid Falling Objects.* Do not necessarily stand where you can be struck by materials dropped by men working overhead.

J. *Stringing Lines.* Never string wire near live lines except by means of suitable insulating hand lines or other appliances. Avoid bringing them in contact with the live lines. Regard them as live wires of the same voltage because of their liability to come in contact with the live lines.

Never change the strains on a pole by adding or removing wires until assured that the pole will stand the altered strains.

In stringing wires do not allow them to sag so as to endanger vehicles or pedestrians below, unless traffic is intercepted by watchmen or otherwise.

K. *Reporting Defects.* Report promptly to your immediate superior any dangerous conditions of your own or other utilities observed arising from defective insulators, pins, cross arms, abnormally sagging wires, etc.

Order 1434. Series Street Lamps.

A. *Application of Rule.* All series-lamp trimmers, hangers, and inspectors shall study and strictly observe the following, in addition to the general rules in 1420 and 1424 and the special rules under the sections for overhead and underground operation, respectively, in 1433 and 1436 which apply to their work.

B. *Precautions on Series Circuits.* Series lamps and devices in series circuits should always be treated as alive unless disconnected by absolute cut outs or protected by the grounding of the circuit.

C. *Handling Series Lamps.* Trimmers, inspectors, or patrolmen shall wear suitable insulating gloves and stand on insulating stools, platforms, or tower wagons, or on dry, well seasoned wood poles while touching series lamps or their cut outs, when these are alive.

Where insulating stools, platforms or tower wagons are used which provide sufficient insulation from ground for the voltages to be handled, the insulating gloves may be dispensed with.

D. *Bridging Series Lamps.* Before working on lamps or other devices in live series circuits always bridge the device with jumpers such as series lamp cut outs usually provide.

Note: This will insure that the circuit will not be opened at the device, and possibly be completed through your body or will not arc at the point of opening and burn you.

E. *Testing Series Lamp Circuits.* Series lamp circuits should not be tested at their full operating voltage unless it is impracticable to test otherwise. Tests should be made only in accordance with a time schedule, concerning which all persons whose safety may be affected are informed.

F. *Periodically Disconnected Circuits.* If circuits, such as series lamp circuits, are not effectively grounded during the idle period, all rules for handling live parts shall be strictly observed.

G. *Reporting Defects.* Report promptly to your immediate superior any abnormally sagging wires, broken insulators, leaning poles, defective pole steps, broken globes or lamp supports, and other defects giving rise to a dangerous condition of your own or other utilities, or any indication of voltage on lines supposed to be dead.

Order 1435. Communication Circuits Used in Connection with Supply Lines.

A. *Application of Rule.* All men working on or near telephone and telegraph lines operated in connection with supply lines shall study and strictly observe the following in addition to all the general rules in section 142 and the special orders 1433 and 1436 which apply to their work. For rules governing the operation of commercial communication lines see sections 144 and 145.

B. *Title of Official in Charge.* In those rules where the words "chief operator" are used the official in charge of safeguarding operation is to be understood.

C. *Precautions Before Climbing Poles.* Make a careful inspection to ascertain if possible whether there are any crosses with supply circuits before climbing poles or other structures to work on or about communication wires, especially where such poles or structures are occupied in common with, or located near power circuits.

Apply mechanical tests as far as practicable to messenger wires before trusting the wires to carry your weight.

D. *Approaching Supply Wires.* Avoid contact with all wires other than those you know to be communication wires, assuming such other wires always to be alive.

Do not approach any supply wire or supply equipment within the distances given in order 1422, B and C, unless you can comply with all the rules under that section, as far as they apply.

Note: Communication wires in trouble may be in contact with supply wires at some distant point, and should be treated with proper care.

E. *Touching Equipment.* While handling communication wires, metal sheaths, or communication equipment avoid touching guy or span wires and supply wires or equipment. Especially avoid standing on or touching transformer cases, hangers, or connections.

While touching open communication wires avoid contact also with grounded parts, such as sheaths and ground wires.

F. *Stringing Wires.* When stringing wires or cables over or under supply lines avoid any possibility of their coming in contact. Do not string them above live supply lines where it is practicable to avoid it.

Where liability of contact can not be entirely avoided, the lines being handled shall be treated as alive (unless they are effectively grounded), and the rules of 1422, so far as they are applicable, shall be carefully observed.

G. *Reporting Dangerous Conditions.* Promptly report to the proper official abnormally sagging wires, broken or defective insulators, pins, cross arms, defective poles, or any other dangerous conditions of your own or other utilities.

Order 1436. Underground Lines.

A. *Application of Rules.* All cable splicers and other workmen in underground construction or operation shall study and strictly observe the following, in addition to the general rules in 1420 to 1424, which apply to their work.

B. *Guarding Manholes, Handholes, and Street Openings.* When removing manhole or handhole covers or making excavations, promptly protect the opening with a barrier, temporary cover, or other suitable guard, and see that danger signals or red lights are displayed in a location conspicuous to the traffic until permanent covers are in place or the excavations are filled.

C. *Testing for Gas.* Do not enter manholes until you have assured yourself that the manholes are free from dangerous gases, by testing with approved safety lamps, by ventilation, or by other adequate methods. (See order 1452, B, for testing for gas.)

D. *Watchman on Surface at Manholes.* Do not enter a manhole unless a temporary cover is placed over the opening or a watchman is stationed at the surface. Where any gas is liable to be present always see that the watchman is stationed at the surface. Where any hazard is involved do not leave a manhole unwatched until all workmen are out.

E. *Avoiding Flames.* Do not smoke in manholes and avoid as far as practicable open flames or torches in or near manholes. Avoid sparks in handling live parts or cable sheaths, and avoid igniting the flux in soldering and wiping joints. In using hot paraffin see that it does not reach a temperature at which it will ignite. (See order 1452, D, for avoiding flames).

F. *Pulling Cables.* When pulling in cables make sure that the gear can not slip so as to injure workmen. Avoid the danger of having the hands drawn into the tackle by the pulling line.

G. *Unidentified Cables.* If lines and cables are not properly identified by markings or positions, do not work upon them.

H. *Testing and Splicing Live Cables.* Always ascertain, if practicable, whether cables are alive, by testing with the test devices provided, before cutting into the cable sheaths. Live cable should be spliced only by men experienced in the work, and they should use extreme caution and suitable devices in so doing.

I. *Reporting Defects.* Promptly report to your immediate superior any dangerous condition of your own or other utilities, whether observed in underground or overhead construction. Particularly report insanitary conditions, gas, or missing cable tags in manholes, and abnormally sagging wires or broken supports in overhead construction.

Order 1437. Tunnel and Subway.

A. *Application of Rule.* Tunnel and subway electricians, operators, and others working on or about underground electrical equipment (not in stations, substations, or in underground conduit systems) shall study and strictly observe the following, in addition to the rules in 1420, 1421, 1422, 1430, and 1436, so far as they apply to their work.

B. *Dangerous Locations.* The value of insulation (insulating covering) as protection from shock is reduced by the dampness usually present in these and similar locations. The restricted spaces often bring the worker closer to equipment and wires than in other kinds of electrical work, and the imperfect illumination also makes special care necessary to avoid contacts. The human body and all surrounding surfaces become more conducting where dampness exists, and electrical shocks are, therefore, more severe.

C. *Live Electrical Parts.* Before handling any electrical equipment or wires make sure whether they are alive or dead.

Note: It is not advisable to work on live equipment or wires when the current can be shut off without interrupting necessary operations.

D. *Unauthorized Work.* Never touch or disturb any electrical equipment or wires without being authorized.

E. *Standing on Ground.* 1. Do not touch any electric wire, cable, or third rail, no matter how well it is insulated, while you are standing on the ground or on a grounded conducting surface, such as a pipe, track, or rail.

2. Do not touch the metal frame or case of a motor if it it is ungrounded, and you are in contact with ground or a grounded object.

Note: Remember that the surfaces of damp ground and water are conducting. Insulation on a wire may look perfect, but it frequently will not prevent shock.

F. *Carrying Tools.* In carrying tools or metal implements in passageways containing electric wires, especially near exposed wires, never permit the tools or implements to touch them.

In particular, do not carry such objects on the shoulder when there are conductors overhead. Do not travel on that side of passageways where third rails or side trolley wires are exposed.

G. *Handling and Repairing Live Parts.* 1. When necessary to handle or repair live trolley wires, third rails, cables, motors, or other electrical equipment, wear suitable

insulating gloves or stand on the waterproof insulating mats or platforms provided, or obtain dry wood free from metal.

Do not rely entirely on gloves for protection.

The gloves may have been punctured since they were previously tested.

2. Before handling or making use of any electrical cable, carefully examine it to make sure that its insulation is not injured.

H. *Inspection of Portable Cables.* Portable cables should be inspected at least once daily during the period of their use.

I. *Handling Portable Devices.* In handling portable motors or lamps, first make sure that the external metal frame is not alive by contact with or leakage from live parts within.

Have such portable devices inspected at least once daily during the period of their use.

J. *Fuses and Switches.* Never handle fuses nor close switches or circuit-breakers unless you are authorized to perform that special duty, and then use the insulating handles or rods provided.

Before closing switches first make sure that you are not endangering other persons.

K. *Injuring Cables and Wires.* Do not fire shots (blasting), handle tools, or perform other work in such a manner as to injure cables or wires in the vicinity. If in doubt, consult your superior.

L. *Temporary Wiring.* Never arrange the wiring of any temporary circuit for earth return, nor use bare conductors.

Note: This particularly applies to the temporary portions of shot-firing circuits and to the leads of portable motors and lamps.

Never employ temporary circuits without seeing that there are installed at the junction with the permanent wiring, suitable disconnecting switches or plug connectors, arranged to disconnect all conductors of the temporary circuit by a single operation.

For shot-firing circuits, their disconnectors should be left open until the shot is to be fired, and should preferably be arranged for locking in the open position.

M. *General Precautions.* Never get on or off locomotives or cars on the side where the trolley wire or third rail is located.

Do not place combustible or explosive materials near electric wires, trolley tracks, third rails, or motors. Do nothing that will cause sparking, or expose parts that may arc or spark during operation, if any explosive gases are present.

N. *Reporting Dangerous Conditions.* Promptly report to your superior any dangerous or unusual conditions observed. In particular, report the presence of gas, broken insulators, bad insulation on wires, defective third-rail construction, live frames of motors, broken ground wires on motor frames, and sparking, arcing, or shocks noticed at any point. Report also any fallen, crossed, or abnormally sagging wires, whether electric wires or not. This includes trolley wires at switches and crossings and wires injured through falling roofs.

SECTION 144. COMMUNICATION SYSTEMS—RULES FOR EMPLOYERS

Order 1440. Distribution and Enforcement of Rules.

A. *Distribution.* The employer shall furnish to each regular employee working on or about commercial telephone or telegraph equipment or lines, or shall post conspicuously, safety rules governing his conduct while so engaged, and shall take suitable means to secure the employee's compliance with the same.

B. *Form.* The safety rules furnished to any employee may be in such form as the employer may determine is best suited to the needs of individual employees. They shall, however, include the principles set forth in the following rules, or at least such part thereof as is applicable to the work in which the employee is engaged, and shall not conflict with these rules.

C. *Interpretation.* If a difference of opinion arises with regard to the meaning or application of these rules, or as to the means necessary to carry them out, the decision of the employer or his authorized agent shall be final, subject to an appeal (if taken) to the regulative body having jurisdiction.

Order 1441. Address List and Emergency Rules.

The rule books should contain or be accompanied by the following:

A. A list of names and addresses of those physicians and members of the organization who are to be called upon in emergencies.

B. A copy of rules for first aid, prone-pressure method of resuscitation, and fire extinguishment.

These should also be kept in conspicuous locations in central offices, on line wagons, and in other locations where the number of employees and nature of the work warrants.

Order 1442. Instructing Employees.

Employees regularly working on or about communication equipment or lines, if their duties render such training necessary, shall be thoroughly instructed in approved methods of first aid, the prone-pressure method of resuscitation, and fire extinguishment, and if advisable, regularly drilled.

Groups of employees, such as commercial telephone operators, shall be thoroughly drilled to make prompt and orderly exit from buildings in case of fire.

Order 1443. Qualification of Employees.

The employer shall use every reasonable means and precaution to assure himself that each employee is mentally and physically qualified to perform his work in accordance with these rules, and that he is not addicted to the use of intoxicants and habit-forming drugs.

Order 1444. Protective Devices.

There shall be provided in conspicuous and suitable places in stations and on line wagons a sufficient supply of suitable protective, first-aid, and fire-extinguishing equipment to enable employees to meet the requirements of these rules. Such devices and equipment shall be inspected or tested to insure that they are kept in good order. The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case:

A. First-aid outfits.

B. Insulating wearing apparel, such as insulating gloves, boots, and shields.

C. Safety Belts.

D. Fire-extinguishing apparatus.

SECTION 145. COMMUNICATION SYSTEMS—RULES FOR EMPLOYEES

Order 1450. General Precautions.

A. *Heeding Warnings, Warning Others.* Employees should cultivate the habit of being cautious, heed warning signs and signals, and always warn others when seen in danger near equipment and lines.

B. *Inexperienced Employees.* No employee shall do work for which he is not properly qualified on or about equipment or lines, except under the direct supervision of an experienced and properly qualified person.

C. *Electrical Supply Equipment or Wires.* Workmen whose duties do not require them to approach or handle electrical supply equipment and wires should keep away from such equipment or wires.

Electrical supply equipment and wires should always be considered as alive unless positively known to be dead.

D. *Safe Supports and Safety Belts.* 1. Safe Supports. Employees should not support themselves on any portion of a tree, pole structure, lamp bracket, or similar fixtures on poles, scaffold, ladder, roof, skylight, or other elevated structure without first making sure that the supports are strong enough, reinforcing them if necessary. Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the supporting surfaces are smooth or vibrating.

Insecure makeshift substitutes for ladders should not be used. An employee should never trust his weight on thin wooden boxes, sinks, washbowls, window shelves, or chair backs.

A ladder should not be placed upon a box, barrel, or other movable or insecure object.

Care should be taken to see that chairs, rolling ladders, and similar equipment are in first-class condition before being used.

2. Safety Belts. Employees should not work in elevated positions unless secured from falling by a suitable safety belt or other adequate means (sometimes including suitably located pole steps). Before an employee trusts his weight to the belt, he should determine that the snaps or fastenings are properly engaged and that he is secured in his belt.

3. Safety Ropes. Ropes used for supporting boatswains' chairs, platforms, or for other purposes on which the security of the employee depends shall be frequently inspected to assure that they are maintained in good condition.

E. *Duties of Foreman.* 1. Duties. Each foreman in charge of work shall see that the safety rules are observed by the employees under his direction. He shall make all necessary records; reporting to his superior when required. He shall permit only authorized persons to approach places where work is being done. He shall adopt such precautions as are within his power to prevent accidents, and prohibit

the use of tools or devices which are defective, or not suited to the work in hand.

2. Qualified Guides. The qualified person accompanying uninstructed workmen or visitors near electrical equipment or lines shall take precautions to provide suitable safeguards and see that the safety rules are observed.

F. *Handling Live Parts.* No employee should touch, with bare hands, any exposed ungrounded live part of more than 150 volts to ground, unless he is insulated from other conducting surfaces, including the ground itself. When employees must touch, at the same time, two parts between which a considerable potential exists, insulating gloves or other protection shall be used.

G. *Power Circuits in Central Offices.* When making repairs on electric light or power circuits, the circuits shall, whenever possible, be made dead.

Where practicable, moving apparatus, as, for example, a fan, shall be stopped before working upon it.

None other than duly authorized persons shall be admitted to central-office transformer vaults or battery rooms.

Care shall be used while working on or near circuits of more than 150 volts to ground, particularly in alternating-current districts.

H. *Handling Fuses or Brushes.* When working on the brushes of a machine in operation, employees shall use care not to break a circuit, the flashing of which may injure the eyes or burn the hands. If it is necessary to remove a brush from the holder, the machine shall be shut down.

When inspecting or changing fuses, care should be taken to prevent injury to the eyes. If it is necessary to handle the fuses, the circuits should be cut off, if possible.

I. *Battery Rooms.* Do not smoke or cause arcing in storage battery rooms. The use of open flames should be avoided, especially while the cells are gassing, and should be permitted only in special cases under the direct supervision of an experienced person and after the room has been thoroughly ventilated.

Order 1451. Overhead Lines.

A. *Precautions to be Observed Before Climbing Structures.* Before climbing poles, ladders, scaffolds, or other elevated structures first assure yourself that the pole, ladder, scaffold, tree, cross arm, messenger wire, cable car, or boatswain's chair, or other elevated support is strong enough to safely sustain your weight.

On pole-replacement work no pole shall be climbed for the purpose of clearing it of all wire and cables without first guying or bracing the pole securely.

Where poles or cross arms are apparently unsafe because of decay, or unequal strains of wire on them, they should be properly braced or guyed, if necessary, before they are climbed.

An uncoiled hand line, rope, or wire of any sort should not be fastened to the employee while climbing a pole, but where this must be done the employee should exercise due care to prevent the line from catching on obstructions.

In climbing poles careful watch should be kept for nails or other foreign attachments which might catch in the clothing and cause a fall.

B. *Use of Pole Steps.* When poles are stepped make use of such steps in climbing, first making sure that the steps are firmly set in solid material before trusting your weight upon them. Pay particular attention, on icy poles, to each step.

Do not support yourself by pins, brackets, or conductors.

C. *Spurs.* Spurs with gaffs worn short shall not be used. The gaffs on spurs shall be kept sharp and spurs shall fit properly. Spurs shall not be worn on work for which they are not required, nor while men are traveling to or from work.

D. *Approaching Supply Lines.* Avoid contact with all wires other than those you know to be communication wires, assuming such other wires always to be alive. Communication wires in trouble may be in contact with supply lines at some distant point, and should be treated as live supply lines unless known to be free from any dangerous voltage.

Do not approach any supply line or supply equipment within the distances given in order 1422 under section 142, unless you comply with all the rules under that section.

E. *Touching Equipment.* While handling communication wires, metal sheaths, or communication equipment avoid touching trolley or arc-lamp span wires and supply lines or equipment. Especially avoid standing on or touching transformer cases, hangers, or connections.

F. *Care About Electrical Supply Lines.* Do not go among any wires until you know their voltage.

Leaning over and crowding through unprotected supply wires should be avoided wherever possible.

Place yourself so that you will not be liable to fall on supply wires should an accident occur.

Do not depend on the insulating covering of wires, and treat all wires as alive unless they have been killed properly (except communication wires known to be clear).

Treat also as alive all wires (unless thoroughly grounded) which are being strung near supply wires; regard them as being of the same voltage as the supply wires.

Avoid use of hand lines or measuring tapes containing metal strands.

When necessary to work in the vicinity of supply wires, transformers, and similar equipment assure yourself before starting work that the position of the body is such that should you momentarily forget yourself or fall, no portion of the body will come in contact with the foreign wires or equipment. Have the supply circuits killed where possible before approaching them.

Railway span wires, pull-offs, and trolley brackets shall be treated as if alive, even though equipped with strain or other insulators.

G. *Stringing Wires.* Never string wires near live circuits except by means of suitable insulating hand lines or other appliances.

Avoid the use of single or paired wires as a substitute for a hand line.

Wires should not be strung above live circuits operating at more than 750 volts, unless the wires being strung are effectively grounded or otherwise suitably protected, or in handling them all the precautions are observed as provided in rule 1422, for work on parts at the voltage of the circuits concerned, and the spacings maintained.

Never change the strains on a pole by adding or removing wires until assured that the pole will stand the altered strains.

When wires are being pulled up on corner poles employees should stand in such a position that they can not be struck by the wire in case it slips.

Where it is necessary to remove communication wires below which are supply wires, power should be shut off of the supply wires where possible, and, if this is not practicable, rope cradles and suitable guards should be erected. Extraordinary care should be exercised to prevent the communication wires from sagging into the supply wires.

In stringing wires, cables, messengers, span wires, or guys do not allow them to sag so as to endanger vehicles or pedestrians below, unless traffic is intercepted by watchmen or otherwise. This may necessitate keeping a watchman at the coil or reel. When stringing wires for long distances, precautions shall be taken to prevent the possibility of vehicles or pedestrians coming into contact with the wires at the intersecting streets or highway crossings.

H. *Protecting Traffic.* When working overhead, keep tools and materials not in use in proper receptacles; tools or materials should not be thrown to or from the man on the pole, but should be raised or lowered by means of a hand-line, using a proper receptacle, if practicable. Also tools and loose materials should not be left at the top of poles, ladders, or other elevated structures.

Workmen shall not stand where they are liable to be struck by materials dropped by men working overhead.

Pole holes, open manholes, excavations, and obstructions along the public highway and other frequented places shall be protected by watchmen, barriers or suitable guards, warning signs, or danger signals so located as to be conspicuous to traffic.

When working overhead or hoisting or lowering materials above places where traffic occurs, a man should be stationed to warn passers-by.

Where traffic is light, warning signs may be used in lieu of watchmen. Where traffic is congested, it may be necessary to rope off the space.

I. *Reporting Dangerous Conditions.* Report promptly to your immediate superior any observed dangerous conditions of your own or other utilities arising from defective insulators, pins, cross arms, abnormally sagging wires, etc.

Any imminently dangerous conditions shall be guarded until they can be made safe.

Order 1452. Underground Lines.

A. *Guarding Manholes, Handholes, and Street Openings.* When removing manhole or handhole covers or making excavations, promptly protect the opening with a barrier, temporary cover, or other suitable guard, and see that danger signals or red lights are displayed in a location conspicuous to the traffic until permanent covers are in place or the excavations are filled.

B. *Testing for Gas.* Do not enter manholes until you have assured yourself that the manholes are free from dangerous gases, as indicated by approved safety lamps, by ventilation, or by other adequate methods.

When work is being carried on in manholes for any length of time where gas collects, suitable ventilation shall be provided, or tests with the safety device should be repeated at regular intervals to make certain that gas is not accumulating in the manhole in dangerous quantities.

C. *Watchman on Surface at Manhole.* Where any hazard to the workmen is involved observe the following:

1. Do not enter a manhole unless a man is stationed at the surface.

2. Do not leave a manhole unwatched until all workmen are out.

D. *Avoiding Flames.* Do not smoke in manholes, and avoid as far as practicable open flames or torches in or near manholes.

If it is necessary to illuminate a manhole, electric lights only should be used. When doing this, it should be known that the leads, sockets, and connections are well insulated and in good condition in order to avoid the possibility of a spark. Special attention should be paid to the sparking of any motors used for ventilating purposes.

Avoid sparks in handling live parts or cable sheaths, and avoid igniting the flux in soldering and wiping joints. In using hot paraffin see that it does not reach a temperature at which it will ignite.

In central-office cable vaults, tests shall be made for the presence of gas before using exposed flames, and such flames shall not be used in vaults where gas collects.

E. *Pulling Cables.* When pulling cables, make sure that the gear can not slip so as to injure workmen. Avoid the danger of having the hands drawn into the tackle by the pulling line.

F. *Reporting Dangerous Conditions.* Promptly report to your immediate superior any dangerous condition of your own or other utilities, whether observed in underground or overhead construction. Particularly report unsanitary conditions, gas, or missing cable tags in manholes and abnormally sagging wires or broken supports in overhead construction.

PART 5

RADIO INSTALLATIONS

Orders formerly contained in this part of the code will be found in Section 133.7.

PART 6

PROTECTION OF BUILDINGS AND STRUCTURES AGAINST LIGHTNING

For complete codes on lightning protection see the following:

1. Code for Protection Against Lightning, Miscellaneous Publication No. 92 of the Bureau of Standards.

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 5/8 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 four-legged 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 system 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 sec-

tions 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 saw-tooth 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 such as radiators, piping systems, electric conduit, tanks, stationary machinery and stanchions, which are often in contact with persons or animals shall not be connected to the lightning conductor. Lightning conductors shall be kept more than six feet from the above mentioned objects.

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. *Ground Connection to Pipe Systems.* No grounding electrode shall be located within 6 feet of any water system of limited extent, gas pipe, electrical conduit or other metal object which enters the building except where the grounding electrode encircles the building as provided in "G" following. Where an extensive waterpipe system is available and where it enters the building, at least one down conductor shall be attached to it at a point immediately outside the basement wall by means of a substantial clamp to which the conductor can be attached by bolts or solder.

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. *Grounding Conduit.* Metal conduits projecting through the exterior walls of rural buildings shall be permanently grounded outside of the building by an independent grounding conductor run from it to an independent grounding electrode as directly as possible.

B. *Metal Radio Masts on Buildings.* Metal radio masts on buildings shall be bonded to the nearest lightning conductor.

C. *Wooden Radio Masts.* Wooden radio masts which extend more than six feet above the ridge or highest parts of the building on which they are placed shall be treated in the same manner as flag poles.

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 com-

parable 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 Flag Poles.* 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.

Order 1641. 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 conductors 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. LIVE STOCK 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 live stock 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 non-conducting 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 hangers, balloons, airships, ships, trees, and structures containing flammable liquids and gases, reference should be made to "Code for Protection Against Lightning", Miscellaneous Publication of the Bureau of Standards No. 92.

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