Industrial Commission of Wisconsin

FRED M. WILCOX, *Chairman* VOYTA WRABETZ

R. G. KNUTSON

A. J. ALTMEYER, *Secretary*

R. McA. KEOWN, *Engineer* JOHN E. WISE, *Electrical Engr.*

Railroad Commission of Wisconsin

ADOLPH KANNEBERG, *Chairman* A. R. McDONALD P. H. PORTER

WM. M. DINNEEN, *Secretary*

C. B. HAYDEN, *Chief Engineer* R. E. PURUCKER, *Ass't. Elect. Engr.*

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.

THIRD EDITION

Effective November 21, 1930

Madison, Wisconsin

DEMOCRAT PRINTING COMPANY
MADISON, WISCONSIN

BEFORE THE

RAILROAD 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 Railroad 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 November 21, 1930.

IT IS THEREFORE ORDERED, That all railroads and public utilities subject to the jurisdiction of this Commission and subject to the requirements of Section 1797*m*—102*o* 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 September 12, 1924.

Dated at Madison, Wisconsin, this 21st day of November, 1930.

RAILROAD COMMISSION OF WISCONSIN,

ADOLPH KANNEBERG, *Chairman,*
A. R. MCDONALD,
P. H. PORTER,
Commissioners.

NOTE—To facilitate the filing of the above information, sample forms will be furnished by the Commission upon application. The utility or railroad is to send duplicate forms of the same type to the Railroad Commission for approval. If the construction is satisfactory, one of the forms, together with the Commission approval, will be returned.

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Wisconsin State Electrical Code

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ERRATA

(January 1, 1931)

The last paragraph of Order 1261A4(c) page 110 states that as soon as the American Engineering Standards Committee adopted new ultimate stresses for wood poles the new values should be applied. The Committee adopted new values in December, 1930 which changes Table 19, page 109 and Table 20, page 111 to the following:

Substitute the following for Table 19 page 109

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
Cypress	5,000
Eastern cedar (Northern white cedar)	3,600
Redwood	3,600

Tables 47 (see p. 163), 48 (see p. 164), 61 (see p. 173), and 62 (see p. 174), were supplied by the Aluminum Company of America. The Aluminum Company claims that the values are based on tests of ultimate strengths of cables. The values of breaking load in Table 71 (page 180) are approximately 90% of the values used by the Aluminum Company.

Add the following to Order 1332.03j on page 329.

without written approval of the Industrial Commission. (See Order 2062 of the Industrial Commission's General Orders on Spray Coating.)

Substitute the following for Table 20 page 111

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

WISCONSIN STATE ELECTRICAL CODE

INTRODUCTION

By Sections 101.1 to 101.31 inclusive, 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. In performance of the first duty the Industrial Commission issued an Electrical Safety Code July 1, 1917, and in performance of the second duty has regulated interior wiring by means of General Orders 5225 and 6037.

Between 1917 and the present date, the 1917 code orders were revised and changed a number of times. The last code was issued January 1, 1925. A supplement to this code was issued August 12, 1927.

In 1929 it became apparent that 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 Railroad Commission at various times during 1929 and 1930.

ADVISORY COMMITTEE

C. B. Hayden, Madison, Chairman of Committee, Railroad 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
A. J. Goedjen, Green Bay, Wisconsin Utilities Association
Frank R. Daniel, Milwaukee, Wisconsin Inspection Bureau
F. H. Runkel, Madison, Commonwealth Telephone Company
George Crowell, 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 Dept.
J. E. Florin, Madison, Industrial Commission of Wisconsin

A. C. Froderman, Milwaukee, Electrical Contractors and Dealers Association of Milwaukee
Joseph Koetting, Wisconsin Federation of Labor
George E. Cooper, West Allis, Wisconsin Manufacturers Association
G. H. Andrae, Milwaukee, Contractor, State Association of Electrical Contractors and Dealers
R. E. Purucker, Madison, Wisconsin Railroad Commission.

The persons consulted as technical advisers were as follows:

V. H. Tousley, Chicago, Electric Field Engineer, National Fire Protection Association
G. G. Post, Milwaukee, Vice President, T. M. E. R. & L. Co.
C. T. Reisz, Chicago, Western Union Telegraph Company
H. R. Huntley, Milwaukee, Transmission Engineer, Wisconsin Telephone Company
C. R. Brown, Madison, Engineer, Commonwealth Telephone Company
W. E. Gundlach, Milwaukee, Engineer, T. M. E. R. & L. Co.
E. J. Kallevang, Madison, Engineer, Wisconsin Power and Light Co.
E. H. Herzberg, Milwaukee, Manager, Milwaukee Branch of the Electrical Contractors and Dealers Association
M. T. Bennett, Wisconsin Railroad Commission

The final formal hearing was held at Madison on June 16, 1930 at which time the committee made a report to the two commissions. After fully considering the committee's recommendations, the attached code was issued. The official publication of this action of the Industrial Commission took place in the official state paper on October 22, 1930 and hence became effective thirty days later; namely, November 21, 1930. The Railroad 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.

The 1929 legislature passed a law known as Chapter 470 of the Laws of 1929 relating to electric wiring. The act is as follows:

AN ACT

To create section 167.16 of the statutes, relating to electric wiring and providing a penalty

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. A new section is added to the statutes to read: 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 electric 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.

SECTION 2. This act shall take effect upon passage and publication.

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 Chapter 470 of the Laws of Wisconsin for 1929.

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 1929	*Subject Matter*
Chapter 101	Creation and duties of Industrial Comm.
Chapter 102	Workmen's compensation act
Chapter 195 and 196	Creation and duties of Railroad Comm.
Section 86.16	Poles on highways
Section 180.17	Location of wires
Section 180.18	Poles and wires at Railroad Crossings.
Section 196.67	Transmission lines and warning signs
Section 196.74	Safety and Interference
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:

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 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

ENFORCEMENT

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

The Railroad 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, 5 and 6.

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 Railroad 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 Railroad 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 Railroad Commission and within the time determined by them.

(C) *Penalties.* Sections 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 Railroad 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) *Approved* means acceptable to the administrative authority enforcing this code.

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

(8) *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.

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

(10) *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)

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

(12) *Cabinet* means an enclosure 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).

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

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

(15) *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.

(16) *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.

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

(18) *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.

(19) *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.

(20) *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.

(21) *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 for horizontal separation between conductors on the same support for the highest voltage carried by either conductor concerned.

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

Flexible conduit means flexible metal tubing into which the wires are drawn after the tubing has been installed. Armored cable is similar flexible metal tubing in which the conductors have been inserted in the process of manufacture.

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.

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

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

(25) *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.

(26) *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)

(27) *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.

(28) *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.

(29) *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.

(30) *Diversity Factor* means the ratio of the sum of the maximum power demands of the subdivisions of the sys-

tem, 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.

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

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

(33) *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)

(34) *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.

(35) *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)

(36) *Enclosed:* See inclosed.

(37) (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.

(38) *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.

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

(40) *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.

(41) *Guarded* means covered, shielded, fenced, enclosed, 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)

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

(43) *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.

(44) *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 ignitable fibres or materials producing combustible flyings are handled, manufactured, stored or used.

(45) *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.

(46) *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.

(47) *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.

(48) *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).

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

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

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

(52) *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)

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

(54) *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)

(55) *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.

(56) *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.

(57) *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.

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

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

(60) *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.

(61) *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.

(62) *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.)

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

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

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

(66) *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).

(67) *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.

(68) *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.

(69) *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)

(70) *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.

(71) *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.

(72) *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.

(73) *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)

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

(75) *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.

(76) *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.

(77) *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.

(78) *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.

(79) *Service* means the connecting conductors by which a supply of electrical energy is carried from a supply line to the building or premises served. For overhead circuits, it includes the conductors from the last line pole to the service switch or fuse. The portion of an overhead service between the pole and building is designated as "service drop".

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

(81) *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.

(82) *Special Permission* means the written consent of the Industrial or Railroad Commission.

(83) *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.

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

(85) *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.

(86) *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.)

(87) *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.

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

(89) *Totally Enclosed 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.

(90) *Transformer vault* means an isolated, fire-proof 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.

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

(92) *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.)

(93) *Vaportight:* So enclosed that vapor will not enter the inclosure.

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

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

(96) *Voltage or Volts* means the highest effective voltage between the conductors of the circuit concerned, except that in grounded multiwire circuits, not exceeding 750 volts between the outer conductors, it means the highest effective voltage between any wire of the circuit and ground.

In ungrounded circuits not exceeding 750 volts, voltage to ground means the voltage of the circuit.

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.

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

(98) *Watertight* means so constructed that moisture will not enter the enclosing case.

(99) *Weather-proof* 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.

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

SECTION 103. METHODS OF PROTECTIVE GROUNDING

Order 1030. General.

The following orders apply to the grounding of all lightning arresters, except those on communication circuits, and of all circuits, equipment, or wire runways when the

grounding is intended to be a permanent and effective protective measure.

They do not apply to the grounded return of electric railways, nor to the grounding of lightning protection wires which are independent of electric circuits or equipment.

These orders do not require that grounding shall be done, but cover the methods for protective grounding. The orders requiring grounding, in accordance with the methods specified below, are included under the various parts of this code.

The orders giving methods of grounding communication circuits and equipment will be found in Section 136 Part 3.

Orders giving methods of grounding low and medium powered radio transmitting stations and receiving sets will be found in Section 156 Part 5.

Order 1031. Points of Attachment of Grounding Conductors to Parts Grounded.

(A) *Direct Current Distribution Systems.* (1) In three-wire direct-current systems the ground connection shall be made on the neutral at one or more supply stations.

(2) In two-wire direct-current systems the ground connection shall be made on one wire at one station only.

(3) No ground connection shall be made at individual services or within the building served. In two-wire systems, the grounded side of the circuit shall be insulated from ground except at the station ground connection.

(B) *Alternating-current Distribution Systems.* (1) In alternating-current distribution systems the ground connection shall be made at the building service and near the transformer (or transformers) either by direct ground connection through an extended water piping system or artificial ground (see order 1033) 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 1035.

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

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

(4) 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.

(5) 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 the building service, two ground wires and two ground electrodes shall be placed at the pole with the transformer.

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

(7) 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.

(8) For an interior system not electrically connected to exterior conductors, the grounding connection shall be made at the transformer, generator, or other source of supply, or at a switchboard, and on the supply side of the first switch controlling the system. If one of the conductors is identified, the grounding connection shall be made to the identified conductor, commonly known as "the white wire".

(9) 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.

(10) When the secondaries of transformers are supplying a common set of mains, fuses if installed shall be located only at such points as not to cause the loss of the ground connections after any fuses in the transformer circuits or mains have been blown.

(11) Alternating-current secondary circuits supplied from a transformer outside the building shall not be grounded inside the building except at the service entrance.

Note: In all cases, multiple grounds are preferable for alternating-current distribution systems, because of the assurance provided against loss of protection by the chance of disconnection of one ground connection.

(C) *Avoidance of Current Flow over Grounding Conductor.* Where low-potential circuits, arresters, equipment, conduit, armored cable, metal raceways and the like are grounded as a protective measure, they shall be so arranged that there will be no objectionable passage of current over the grounding conductors. The temporary cur-

rents, which are set up under accidental conditions while the grounding conductors are performing their intended functions, are not to be considered 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 connecting the grounding connections shall be suitably interrupted, or (4) other means shall be taken to limit the current.

(D) *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.

(E) *Equipment and wire runways.* (1) 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.

(2) For conduit, armored cable or metal raceways the grounding conductor shall be attached near the point where the conductors of the system receive their supply.

(3) If the conduit system is mechanically and electrically continuous, or all disjoined parts are electrically bonded together, a single ground on the service conduit will suffice.

(4) No separate grounding conductor shall be required for non current carrying parts of equipment if grounded through the conduit, cable sheath or metal raceway system of the building by means of standard locknuts and bushings or by a separate bond between the equipment and the conduit, armored cable, or metal raceway system.

(F) *Connections to be Avoided and Recommendations.* (1) No electric conductor or non current 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 system, parts of which are at times in contact with persons or animals.

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.

(2) The ground connection should be made to that point of the system which will enable making connection to an extended water system rather than artificial grounds.

(3) In installations such as farms where there is more than one building wired and there is no extended water system the conduit and neutral wire shall be grounded to an artificial ground at the service entrance. At each of the other buildings the conduit shall be grounded to an independent artificial ground.

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

Order 1032. Ground Conductor.

(A) *Material and Continuity.* (1) The conductor for grounding an interior wiring system shall be a copper wire or a wire of non-corrodible material of equivalent conductance, and shall be without joint or splice if practicable. If joints are unavoidable they shall be so made and maintained to be electrically and mechanically equivalent to the conductor. For grounding conduit, equipment, and the like, the conductor may be of copper or may be a rigid electrical conduit or pipe, except that under conditions favorable to corrosion, copper only shall be used. For grounding equipment, devices and the like, there may be used the metal enclosures of the wires which supply them or separate grounding wires run in wire assemblies with the circuit conductors.

(2) When parts of the conduit system are used for grounding equipment, conduit, etc., on circuits operating with any conductor at more than 150 volts to ground, the electrical continuity of the conduit system shall be secured by one of the following methods:

(a) Approved threaded fittings with joints made up tight
(b) Approved threadless fittings with joints made up tight
(c) Bonding jumpers with proper fittings
(d) Two locknuts, one inside and one outside of boxes or cabinets

(3) No automatic cutout, or switch for interior wiring systems shall be placed in a grounding conductor, unless the opening of the cutout or switch disconnects all sources of energy.

(4) 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.

(B) *Size and Capacity.* (1) 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 or the system to which it is electrically connected.

(2) The grounding conductor for a direct-current system shall have a current-carrying capacity not less than that of the largest feeder of the same system leaving the station. In no case shall the grounding conductor be smaller than No. 8.

(3) The grounding conductor for an alternating-current circuit or system shall have a current-carrying capacity not less than one-fifth that of the conductor to which it is attached. In no case shall the grounding conductor be smaller than No. 8.

(4) 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, but shall be kept at a distance of at least 20 feet where practicable. 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.

(5) The size of the wire or pipe used for grounding the service conduit shall be not less than that given in the following table:

Nominal Size of Rigid Steel Conduit Service	Grounding Conductor If Wire, No.	If Pipe, Size
¾–1	8 gauge	½ inch
1¼—1½	6 gauge	½ inch
2	4 gauge	¾ inch
2½	2 gauge	¾ inch
3	0 gauge	1 inch
3½–4	00 gauge	1 inch
above 4	000 gauge	1 inch

(6) The size of the wire or of the pipe used for grounding interior conduit, armored cable, metal raceway, fixed equipment and the like, shall be not less than that given in the following table:

Capacity of Automatic Overload Protective Device in Circuit Ahead of Equipment, Conduit, etc. not exceeding (Amperes)	Size of Copper Wire	Nominal Size of Grounding 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

Where pipe is used as a grounding conductor, as in last column of above table, the connections thereto shall be made by means of an approved connector. Threaded connections are preferable, especially where the pipe or conduit is not provided with a conducting coating such as galvanizing.

This table does not apply to the grounding conductor when in non-metallic sheathed cable.

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

(C) *Insulation and Guarding.* (1) The installation of the grounding conductor for systems, when not consisting of or enclosed in metallic piping, and the insulating covering of the conductor shall comply with all requirements of this code applying to wires of the voltage of the circuit to which the grounding conductor is attached. Where a grounding conductor, except for an interior wiring system with independent 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.

Exceptions: 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, ground 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 conductor 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 non-magnetic material, unless the grounding conductor is electrically connected to both ends of the protective covering.

Order 1033. Nature of Ground Connection.

(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 to extensive 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 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. 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, artificial grounds which will secure the desired permanence and conductance shall be employed or the use of an extended system ground wire which is properly grounded should be resorted to.

(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.

(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 1035. In such cases the grounding conductor must be guarded according to Order 1032–C–5.

(E) *Grounds to Railway Returns.* Protective ground connections for circuits other than railway circuits shall not be made to railway negative return circuits.

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

Order 1034. Method of Connecting to Ground.

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

Exception: (1) When water meters are located outside of buildings or in concrete pits within buildings where piping connections are imbedded in or under concrete flooring, or other flooring reasonably insuring against the disturbance of water pipe, the ground con-

nections may be made on the building side of the meters, if meters are suitably shunted.

(2) Ground Connection for non current-carrying parts such as equipment or metal raceway systems, (but not for circuits) may be made to the water-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.

(B) *How to Make Connection.* 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.

Note: Such ground connection to metallic piping systems should be made by means of an approved connection firmly fastened to the pipe, after all rust and scale have been removed or by means of a brass plug which has been tightly screwed into a pipe fitting, or where the pipe is of sufficient thickness, screwed into a hole in the pipe itself, or by other equivalent means.

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.

(C) *Artificial Grounds.* Where artificial grounds are used they shall as far as practicable, be embedded below permanent moisture level. Each buried-plate electrode shall present not less than 2 square feet of surface to 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. 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 non-ferrous materials or their approved equivalent used for electrodes shall be not less than ½ inch in diameter. Driven electrodes of pipe or rods, when of less than standard commercial length, shall preferably be of one piece and shall be driven, except where rock bottom is encountered, to a depth of at least eight feet regardless of size or number of electrodes used.

(D) *Contact Surfaces.* Where a non-conductive protective coating such as paint or enamel is used to protect the equipment, conduit-couplings and fittings, such coating shall be completely removed from threads and other surfaces in order to insure a good contact between ground clamp and equipment. Pipes and rods used as ground electrodes shall have clean metal surfaces, and shall not be covered with paint, enamel, or other poorly conducting materials.

Order 1035. Ground Resistance.

(A) *Limits.* The combined resistance of the grounding wire and the connection with the ground shall not exceed 3 ohms for water-pipe connections nor 25 ohms for artificial (buried or driven) grounds. Where it is impracticable to obtain with one ground artificial ground resistance as low as 25 ohms, this requirement shall be waived, and at least two artificial grounds at least six feet apart and with combined area of not less than 4 square feet, shall be provided.

Exception: See order 1033–d–3.

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.

(B) *Checking.* (1) Grounds on distribution circuits and in stations should be tested for resistance when installation is made unless multiple grounding to water-piping systems is used.

(2) 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.

Note: Periodic tests of arrester grounds are not required by this order.

Order 1036. Separate Grounds and Ground Conductors.

(A) *Grounding Conductors.* Grounding conductors from equipment and circuits of each of the following classes, when required by these rules, shall be run separately to the grounding electrode (or to a sufficiently heavy station grounding bus or system ground cable which is well connected to ground at more than one place and has a ground resistance less than 3 ohms.)

(1) Lightning arresters.

(2) Secondaries connected to low voltage lighting or power circuits.

Supplement

(3) Secondaries of current and potential instrument transformers and cases of instruments on these secondaries.

(4) Frames of direct-current railway equipment and of equipment operating in excess of 750 volts.

(5) Frames of utilization equipment or wire raceways other than covered by item (4), except that if a secondary distribution system has multiple grounds to water piping, service conduits may utilize the same grounding conductors.

(6) Lightning rods. (See Order 1031 f, 4 and Part 6.)

(B) *Arrester grounds.* Lightning-arrester ground connections shall not be made to the same artificial ground (driven pipes or buried plates) as circuits or equipment, but should be well spaced and where practicable, at least 20 feet from other artificial grounds.

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 Order 1300 (b) Section 130, Part 3.)

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

SECTION 111. GENERAL PROTECTIVE ARRANGEMENTS OF STATIONS AND SUBSTATIONS

Order 1110. General Requirements for Rooms and Spaces.

(A) *Enclosure of Rooms and Spaces.* Rooms and spaces shall be arranged with fences, screens, partitions, or walks 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)

(4) Ventilation. They should be well ventilated.

(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 Orders 2113 and 2114 of 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. Any such appliances which have not been approved by Underwriters' Laboratories for use on live parts should be plainly and conspicuously marked with a warning to that effect.

Note: Fire extinguishers employing carbon tetrachloride or carbon dioxide as the extinguishing agent are recommended.

Fire extinguishers shall not be installed in locations subject to conditions of high or low temperature which will reduce their effectiveness.

Caution: Carbon tetrachloride extinguishers should not be used in confined spaces, because of the possibility of asphyxiation of the user.

Tetrachloride extinguishers are not adversely affected by temperatures between 60° C (140° F) and minus 40° C (—40° F).

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 noninflammable 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 "gener-

ating 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 Non-current 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 non-current-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 non-current-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 non-current-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 non-current-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 non-current-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		3		4
Voltage Between Phases	Minimum Vertical Clearance of Unguarded Parts		Minimum Horizontal Clearance of Unguarded Parts		Minimum Clearance from Guards to Parts. Radius of Guard Zone
	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. Toe boards 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 of 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 non-current-carrying metal parts of equipment in these locations shall be permanently grounded as specified in Section 103.

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 non-current-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 motors 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.)

(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 non-combustible, 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, nonabsorptive 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-con-

ductor 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 or metal sheath.* Conductors in locations where flammable gas normally exists shall be in metal conduit or metal-sheathed cable. All fittings and outlets of such conduit and cable shall be electrically and mechanically continuous with the conduit or metal sheath, and the conduit shall be sealed to prevent entrance of gases.

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 (e))

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 Non-current-Carrying Metal Parts.

Exposed non-current-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, labeled, or arranged so as to afford ready means for identifying circuits or equipment supplied through them, in accordance with Order 1123.

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 non-current-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 non-current-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. *Non-current-carrying Parts.* Ungrounded metal-sheathed service cables, service conduits, metal fixtures, and similar non-current-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 non-current-carrying parts is permitted by Order 1215B and Order 1280A–4.

C. *Marking of Poles Carrying High Voltages.* 1. When poles or structures carrying voltages of 6000 or more are within 100 feet of any school, within 100 feet of any place where such line crosses a public highway or within the corporate limits of any city or village, warning signs shall be placed on all such poles or supporting structures of such line.

2. Every such sign shall be stenciled on such pole or structure in black or red letters not less than two inches high on a white background and shall read DANGER HIGH VOLTAGE.

3. 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.

Note: The Railroad Commission of Wisconsin has arranged to furnish at cost proper stencils for the marking of poles in compliance with this order. (See Section 196.67 of Laws of 1927)

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 communication 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 Railroad 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.

Sample blanks will be furnished by the Railroad Commission for requests to build joint lines.

SECTION 123. CLEARANCES

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.

E. *Statutes.* Sections 86.16 and 180.18 of the laws of 1929 give clearance requirements.

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	c18
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

Location on pole	Voltage		
	0 to 750 volts	750 to 15,000 volts	More than 15,000 volts
	Feet	Feet	Feet
Side of pole adjacent to vehicular traffic	14	16	18
Side of pole not adjacent to vehicular traffic	8	11	13

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.

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.

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 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
	Inches	
Communication conductors	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	
Vertical and Lateral conductors.	Inches	Inches	Inches	Inches	Inches
Of same circuit	3	3	3	3	0.25
Of other circuits	3	3	6	6	.4
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 sep-

aration 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.

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. 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

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 Non-current-Carrying Metal Parts of Equipment.* For the purpose of measuring these separations metal supports for conductors are considered as non-current-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—		
Same circuit	3	.25
Different circuits	6	.4
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), (c), and (d) 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 cover-

ing (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) and (d) below.

(c) Vertical conductors in metal-sheathed cables and grounding wires may be run without the insulating protection specified in (b) above when installed on poles used only for supply lines and employing side-arm construction, if the line conductors are carried only on the side of the pole opposite to the vertical conductors, and if climbing space is provided on the line conductor side of the pole.

(d) 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

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Communication conductor grades	
Major lines	Minor lines
D	D
A	A
E	E
B	B
A	B

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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
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.

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.

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.

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.

Note: See section 180.18 of 1929 Statutes for additional Railroad Crossing requirements.

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)	33 1/3	50	75
For longitudinal strength (at all times) in general	100	100	
At deadends	33 1/3	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 calculated 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	1/4	5/16
For other localities	5/16	1/8
Painted	1/4	a1/4

a. Painted bracing members having L/R not exceeding 125 may be 3/16 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, cleaning, 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.
Dense yellow pine (meeting standard of A. S. T. M. see Appendix G)	6,500
Other yellow pine	5,000
Chestnut	
Western cedar (western red cedar)	
Cypress	
Eastern cedar (northern white cedar)	3,600
Redwood	

Tests are under way to determine ultimate stresses of woods and when values for ultimate stresses have been adopted as standard by the American Engineering Standards Committee, the values thus determined shall be applied under this code and the values in Table 20 adjusted proportionately.

(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		For ultimate fiber stress of		
	6,500	5,000	3,600	5,000	3,600	6,500	5,000	3,600
At crossings:								
Poles in lines of one grade of construction throughout.								
Grade A	2,170	1,670	1,200	1,670	1,200	3,250	2,500	1,800
Grade B	3,250	2,500	1,800	2,500	1,800	4,870	3,750	2,700
Grade C	4,870	3,750	2,700	3,750	2,700	9,750	7,500	5,400
Poles in isolated sections of higher grade of construction in lines of a lower grade of construction.								
Grade A	2,170	1,670	1,200	1,250	900	3,250	2,500	1,800
Grade B	3,250	2,500	1,800	1,670	1,200	4,870	3,750	2,700
Grade C	4,870	3,750	2,700	3,000	2,160	9,750	7,500	5,400
Elsewhere than at crossings:								
Grade A	2,600	2,000	1,440	1,670	1,200	3,900	3,000	2,160
Grade B	3,900	3,000	2,160	2,500	1,800	6,500	5,000	3,600
Grade C	6,500	5,000	3,600	3,750	2,700	9,750	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 provided 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 deadends	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 un-

balanced 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	
		Supply	Communication
	Inches	Inches	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				
			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 or brace the crossing poles as specified in Order 1262, C the requirements there given may be met by head-guying and side-guying the line as near as practicable to the crossing, but at a distance not exceeding 500 feet from the nearest crossing pole, provided that the line is approximately straight and that a stranded steel wire of strength equivalent to that of the head guy is run between the two guyed poles, being attached to the guyed poles at the point at which the head guys are attached, this wire being securely attached to every pole between the guyed poles.

4. Pole Locations at Crossings. Where communication lines cross over railroads, the poles shall be located as follows:

(a) The poles supporting the crossing span and the adjacent spans should be located in a straight line, if practicable. Where the poles supporting the crossing span and the adjacent spans are not in line, additional guying shall be placed to take care of the unbalanced load.

(b) The crossing span shall be as short as practicable, and in general, shall not be longer than the normal span of the line. No crossing span shall exceed 125 feet in length if this can be avoided.

5. Freedom from Defects. Wood poles supporting the crossing span shall be selected timber, sound and reasonably straight.

6. Minimum Pole Sizes. Poles shall have top diameters not smaller than the values given in Table 24 below.

TABLE 24

Minimum Pole Sizes for Grades D and E

Number of wires carried by pole	Diameter of top of pole	
	Grade D	Grade E
	Inches	Inches
1 to 20	6	6
21 to 40	7	6
More than 40	8	7

7. Spliced Poles. Spliced poles shall not be used at Grade D or E crossings or conflicts.

8. Poles located at Crossings over Spur Tracks. Where a communication line paralleling a railroad track on the right of way of the railroad crosses a spur or stub track without any change in the general direction of line, the transverse strength requirements for grade E construction may be met without the use of side guys, providing the pole is not stressed beyond one-half its ultimate strength. No requirements for longitudinal strength are made if the conductor tensions are balanced. Where conductor tensions are not balanced, due to a small angle in the line at one or both poles, or to dead-ending any of the wires, either guys or braces shall be installed capable of withstanding such unbalanced tensions.

9. Height of Poles Adjacent to Crossing Poles. The height of poles adjacent to crossing poles shall be such that the vertical distance from the top cross arm of the crossing pole to a straight line connecting the top cross arms of the next adjacent poles on either side of this crossing pole shall not exceed the values given below:

Average Length of Span	Allowable Vertical Distance Feet
Less than 100 feet	4
100 to 130 feet	5
Exceeding 130 feet	6

B. *Pole Settings.* Poles shall be set to such a depth and in such a manner and back filling shall be so thoroughly tamped that the applied load will break the pole before the butt is pulled loose from its setting.

Recommendation: A table of recommended depths of setting is given in Appendix F.

C. *Guys.* 1. General. The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (sec. 128).

2. Where Used. Side guys or braces shall be used on poles supporting the crossing span to withstand the loads put upon them in accordance with the conditions specified in Order 1254, B.

Head guys shall be installed in accordance with Table 25.

Exception 1: Side guys are not required where the crossing poles have the transverse strength specified in Order 1262 A, 1. Head guys are not required where the crossing poles carry not more than two wires and have the strength specified in Order 1262 A, 1.

Exception 2: This rule does not apply to crossing poles under the special conditions set forth in Order 1262 A, 3 above.

Exception 3: Where an overhead crossing which makes an angle with the tracks of less than 45° involves at either crossing pole an angle in the pole line, the side guy within the angle may be omitted.

Exception 4: Guying may be omitted where communication lines cross over spur or stub tracks as provided in Order 1262 A, 8.

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

(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 B)

(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
4,000	30,000
6,600	40,000
11,000	50,000
22,000	75,000
33,000	100,000
44,000	125,000
55,000	150,000
66,000	175,000
88,000	220,000
110,000	315,000
132,000	390,000
150,000	420,000
200,000	560,000

(Interpolate for intermediate values)

Order 1275. Factory Tests.

Each insulator or part thereof for use on lines operating at voltages in excess of 15,000 volts shall be subjected to a routine flash-over dry test at the factory for a period of three minutes at a frequency of 60 cycles per second or to any other test sanctioned by good modern practice, such as high-frequency tests.

Order 1276. Selection of Insulators.

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

B. *Insulators for Nominal Line Voltages.* In selecting insulators of the test voltage to be used for any nominal line voltage, consideration shall be given to the conditions under which the line will operate and to the presence of crossings as follows:

1. Where the system is of moderate extent with grounded neutral in open country subject to intermittent rains and moderate lightning and uses wood poles with suspension or pin-type insulators, insulators of the flash-over voltage required in Table 33 for the contemplated line voltage shall be used.

2. Where operating conditions are more severe than set forth in 1 above, due to steel construction, extent of system, use of ungrounded neutral, prevalence of exceptionally

severe lightning, bad atmosphere due to chemical fumes, smoke, cement, dust, salt fog, or other foreign matter, or to a long dry season with heavy dust accumulation followed by moisture, larger insulators than the minimum specified in Table 33 should be used. The amount of increase is to be determined by local experience.

3. At crossings over steam railroads or over communication lines other than minor communication lines where grounded construction or ungrounded metallic pin or cross-arm construction is used, but where the line elsewhere is of wood-pin construction the insulator shall have a dry flash-over test voltage of not less than 25 per cent greater than given in Table 33.

Exception: The 25 per cent increase does not apply if all the insulators in the line are of the suspension type or if construction in accordance with Order 1278 below is employed.

Order 1277. Protection Against Arcing.

In installing the insulators and conductors, such precautions as are sanctioned by good modern practice shall be taken to prevent, as far as possible, any arc from forming or to prevent any arc which might be formed from injuring or burning any parts of the supporting structures, insulators or conductors which might render the conductors liable to fall.

Order 1278. Compliance with Order 1277 at Crossings.

At crossings, construction in accordance with the following methods will be considered as a means of meeting the requirements of Order 1277 above.

A. *Pin-Type Insulators.* 1. Double Construction. Double cross arms, pins, insulators, and conductor fastenings on the crossing supports.

2. Insulation at Crossing Supports. (a) Insulators which meet the minimum values as given in Table 33 and have a rating not less than those in the remainder of the line under the following conditions:

(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:

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).

(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 stenciling signs on a creosoted surface metal signs may be used on creosoted poles in locations and as noted in Order 1214c.

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 1929 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 con-

ductor 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 130.9 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 thereon. 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.

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 1360.06 & 1360.07 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

Location on pole	Voltage		
	0 to 750 volts	750 to 15,000 volts	Exceeding 15,000 volts
	Feet	Feet	Feet
Side of pole adjacent to vehicular traffic	14	16	18
Side of pole not adjacent to vehicular traffic	8	11	13

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	4.4	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	12.3	27.7	------	------	------	------	------	------
		60	6.5	16.9	32.8	------	------	------	------	------	------
		90	9.7	21.6	37.1	------	------	------	------	------	------
	C	30	2.6	5.1	10.6	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.									
		30	2.9	5.4	10.4	32.6	67.2				
	A and B	60	3.6	7.2	14.4	39.4	72.6				
		90	5.0	10.2	19.4	45.1	79.2				
4		30	2.2	3.6	5.7	14.9	36.0				
	C	60	2.6	4.2	7.2	19.2	48.8				
		90	3.1	5.4	9.4	25.0	51.6				
		30	2.6	4.5	7.2	16.8	36.0	99.1	240		
	A and B	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		
2		30	2.2	3.3	5.0	10.1	19.8	62.2	176		
	C	60	2.4	3.9	5.7	12.5	26.2	72.2	186		
		90	2.9	4.8	7.5	15.8	31.2	81.5	196		
		30	2.6	4.5	6.8	14.9	31.2	82.3	203	438	
	A and B	60	3.4	5.7	9.0	19.7	36.6	90.7	212	447	
		90	4.6	7.5	11.9	25.0	44.4	100.0	221	454	
1		30	2.2	3.3	5.0	10.1	17.4	51.2	146	338	761
	C	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
		30	2.6	4.2	6.5	12.5	23.4	63.0	161	349	787
	A and B	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
0		30	2.2	3.3	5.0	9.1	15.6	38.6	113	270	624
	C	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
		30	2.6	4.2	6.5	12.5	21.6	54.6	140	307	682
	A and B	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
00		30	2.2	3.3	4.7	9.1	15.0	36.1	96	232	535
	C	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
		30	2.6	4.2	6.1	11.5	18.6	42.0	102	222	506
	A and B	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
0000		30	2.2	3.3	4.7	8.6	13.8	30.2	73	160	396
	C	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.							
		30	10.2	29.7	50.4				
8	C	60	13.3	31.5	53.6				
		90	17.2	35.1	56.6				
		30	8.7	23.1	37.1				
	A and B	60	12.2	26.6	44.7				
		90	15.6	30.6	48.1				
6		30	4.1	9.7	22.5	38.9			
	C	60	5.4	12.7	27.7	44.1			
		90	7.2	16.9	32.0	48.5			
		30	4.4	9.6	18.4	32.8	48.7		
	A and B	60	6.1	12.4	23.0	38.0	54.2		
		90	8.2	16.6	28.1	42.9	58.8		
4		30	2.9	5.3	9.2	16.2	26.4		
	C	60	3.7	6.6	11.5	20.2	32.6		
		90	4.6	8.4	15.1	25.4	38.9		
		30	3.8	6.6	11.2	18.7	28.3	55.5	90.0
	A and B	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
2		30	3.0	4.8	7.4	11.3	16.3	33.3	60.2
	C	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
		30	3.6	6.1	9.7	15.5	22.6	44.4	73.4
	A and B	60	4.6	7.8	12.6	19.7	28.1	52.2	81.8
		90	6.2	10.8	16.7	24.6	34.1	58.2	88.2
1		30	2.8	4.6	6.8	10.1	13.9	27.3	46.1
	C	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
		30	3.7	6.0	9.4	14.1	20.6	38.4	62.6
	A and B	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
0		30	2.8	4.6	6.8	9.9	13.7	24.6	41.0
	C	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
		30	3.6	6.0	9.0	13.2	18.5	33.6	54.0
	A and B	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
00		30	2.6	4.6	7.0	9.7	13.2	22.8	36.0
	C	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
		30	3.7	6.0	9.0	12.6	17.5	28.8	45.0
	A and B	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
0000		30	2.9	4.6	6.8	9.7	12.7	20.4	32.4
	C	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			
	A and B	30	22.8	39.3	60.1			
		60	25.8	42.5	62.8			
		90	28.4	45.3	65.5			
4	C	30	14.5	28.3	45.5			
		60	18.1	32.0	48.9			
		90	21.6	35.0	50.4			
	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	
2	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	
	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	
1	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	
	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	
0	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	
	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	
00	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	
	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	
0000	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 (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						
	A and B	30	4.7	12.0	24.5						
		60	7.4	16.0	28.5						
		90	11.0	20.0	32.0						
6	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
	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
4	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 (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	
	A and B	30	15.0	37.0	65.0	136	231	357	487	
		60	20.5	45.5	72.0	143	237	362	492	
		90	26.0	50.0	78.0	148	242	367	498	
4	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 (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
	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
4	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.									
		30	3.8	8.9	19.0	32.5	48.0	86.0	131	250	406
	A and B	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
¼		30	2.3	4.5	8.5	16.0	28.0	58.0	97.0	195	323
	C	60	2.0	5.9	11.4	20.5	33.0	68.0	102	200	328
		90	3.8	7.8	15.0	25.0	38.0	68.0	106	205	332
		30	2.6	4.8	7.9	13.0	20.5	43.0	72.0	147	241
	A and B	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
5/16		30	1.9	3.3	5.2	7.8	11.5	24.0	44.0	105	185
	C	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
		30	2.4	4.2	6.7	10.1	14.5	29.0	49.5	107	183
	A and B	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
3/8		30	1.9	3.1	4.7	6.7	9.6	17.5	30.0	73.0	134
	C	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
		30	2.3	3.9	5.8	8.4	11.5	21.0	34.0	75.0	131
	A and B	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
7/16		30	1.9	3.0	4.3	6.3	8.6	14.5	22.5	50.0	92
	C	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
		30	2.3	3.7	5.6	8.0	11.0	19.0	30.0	66.0	116
	A and B	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
½		30	1.9	3.0	4.3	6.1	8.2	13.5	21.0	44.0	80
	C	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
		30	2.3	3.6	5.4	7.6	10.3	17.0	26.5	54.0	94
	A and B	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
9/16		30	1.9	3.0	4.3	5.9	7.7	12.5	19.5	38.5	66
	C	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
		30	2.2	3.6	5.4	7.6	10.1	16.0	25.0	49.0	85
	A and B	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	11.3	15.5	24.5	35.5	65.0	103
5/8		30	1.9	3.0	4.3	5.9	7.7	12.5	18.5	35.5	61
	C	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.								
		30	10.3	20.5	39.5	96.0	166.0	270	381	792
	A and B	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
3/8		30	6.5	10.8	17.5	39.5	77.0	137	208	499
	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	496
7/16		30	6.0	9.9	15.0	30.0	55.0	93	144	358
	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
½		30	6.2	9.9	15.0	29.0	50.0	82	123	312
	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
9/16		30	6.0	9.5	14.0	25.5	44.0	69	103	253
	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
5/8		30	5.8	9.4	13.5	25.5	42.0	64	93	227
	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.								
		30	4.3	6.9	10.4	22.0	43.0	78.0	134	391
	A and B	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 or 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.									
		30	12.5	24.6	42.1	------	------	------	------	------	------
	A and B	60	18.2	30.3	47.2	------	------	------	------	------	------
		90	23.0	35.1	51.8	------	------	------	------	------	------
1		30	4.3	12.3	26.6	------	------	------	------	------	------
	C	60	9.4	20.1	33.5	------	------	------	------	------	------
		90	16.1	26.4	39.6	------	------	------	------	------	------
		30	7.4	16.2	31.0	63.4	109.0	170.0	294	------	------
	A and B	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	------	------
0		30	2.9	7.2	15.5	45.1	81.0	127.0	239	------	------
	C	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	------	------
		30	5.0	10.8	22.0	49.4	85.2	127.0	241	------	------
	A and B	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	------	------
00		30	2.6	5.1	9.7	29.7	60.6	96.5	189	------	462
	C	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
		30	3.8	7.5	14.0	37.4	73.2	102.0	197	------	469
	A and B	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
000		30	2.2	4.2	6.8	20.6	45.0	74.2	151	------	376
	C	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
		30	3.1	6.0	10.4	29.3	53.4	83.5	165	------	395
	A and B	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
0000		30	2.2	3.6	6.1	14.9	31.8	57.6	125	------	312
	C	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 strengths fo 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.									
		32	5.4	9.0	30.2	110.6					
	A and B	60	6.6	10.8	34.2	114.0					
4		120	9.0	16.8	40.2	121.2					
		32	5.4	8.8	11.8	59.0					
	C	60	6.6	10.6	14.4	64.2					
		120	9.0	15.6	22.2	74.4					
		32	5.4	9.0	12.6	58.4	138.0				
	A and B	60	6.6	10.8	15.6	67.2	143.0				
2		120	9.0	16.8	25.0	76.2	153.2				
		32	5.4	8.8	11.8	24.0	81.0				
	C	60	6.6	10.6	14.4	31.4	87.0				
		120	9.0	15.6	22.2	40.6	97.2				
		32	5.4	9.0	12.6	39.6	103.2	187.4			
	A and B	60	6.6	10.8	15.6	48.2	110.4	190.8			
1		120	9.0	16.8	25.0	52.8	121.2	204.6			
		32	5.4	8.8	11.8	18.2	50.4	111.0			
	C	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			
		32	5.4	9.0	12.6	24.6	73.8	144.0			
	A and B	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			
0		32	5.4	8.8	11.8	18.2	35.0	85.8	154.2		
	C	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		
		32	5.4	9.0	12.6	19.8	50.6	110.1	183.6		
	A and B	60	6.6	10.8	15.6	24.6	63.6	123.6	197.0		
00		120	9.0	16.8	25.0	40.6	81.2	140.6	211.2		
		32	5.4	8.8	11.8	18.2	26.4	57.6	110.4		
	C	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		
		32	5.4	9.0	12.6	19.8	40.2	85.4	147.0		
	A and B	60	6.6	10.8	15.6	24.6	51.8	99.8	162.0		
000		120	9.0	16.8	25.0	40.6	72.0	121.2	181.4		
		32	5.4	8.8	11.8	18.2	25.0	46.8	88.2	147.6	
	C	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	
		32	5.4	9.0	12.6	19.8	33.4	66.6	117.0	180.0	
	A and B	60	6.6	10.8	15.6	24.6	42.6	81.6	134.4	197.4	
0000		120	9.0	16.8	25.0	40.6	64.2	105.2	157.0	220.6	
		32	5.4	8.8	11.8	18.2	25.0	38.4	69.6	109.8	172.2
	C	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.									
		30	168	76	48						
8	C	60	116	57	41						
		90	77	48	38						
		30	268	152	97						
	A and B	60	185	111	82						
6		90	124	87	72						
		30	478	367	251	161					
	C	60	385	277	183	128					
		90	297	196	137	105					
		30	640	525	401	297	228	179	156		
	A and B	60	496	391	293	233	192	163	148		
4		90	355	274	215	184	166	146	140		
		30	891	823	721	614	502	320	240		
	C	60	748	676	581	483	387	264	218		
		90	597	535	447	359	300	228	197		
		30	1,104	1,023	911	791	678	496	412	339	313
	A and B	60	875	788	700	590	522	417	365	323	305
2		90	639	577	511	449	409	349	331	311	295
		30	1,448	1,377	1,305	1,226	1,122	899	700	496	417
	C	60	1,216	1,143	1,080	997	903	723	584	454	397
		90	976	913	851	794	705	572	491	418	378
		30	1,379	1,304	1,205	1,113	988	780	636	518	472
	A and B	60	1,080	1,008	944	852	754	622	544	481	455
1		90	803	753	688	642	590	518	484	452	432
		30	1,788	1,742	1,676	1,575	1,500	1,277	1,080	780	645
	C	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
		30	1,732	1,657	1,566	1,471	1,350	1,143	954	771	692
	A and B	60	1,375	1,276	1,214	1,131	1,056	900	812	700	655
0		90	1,007	954	896	854	808	750	692	646	622
		30	2,221	2,171	2,080	1,994	1,919	1,740	1,521	1,168	979
	C	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
		30	2,128	2,055	1,982	1,878	1,763	1,538	1,366	1,116	1,001
	A and B	60	1,654	1,596	1,549	1,456	1,382	1,236	1,142	996	934
00		90	1,215	1,178	1,142	1,095	1,058	1,001	960	908	882
		30	2,731	2,670	2,608	2,513	2,430	2,231	2,042	1,669	1,434
	C	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
		30	3,171	3,107	3,080	2,948	2,890	2,658	2,432	2,168	1,985
	A and B	60	2,426	2,392	2,342	2,292	2,250	2,083	2,010	1,885	1,810
0000		90	1,735	1,718	1,718	1,726	1,735	1,694	1,676	1,694	1,676
		30	4,001	3,960	3,928	3,850	3,792	3,593	3,430	3,053	2,721
	C	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.									
		30	650	538	400	230½	176				
	A and B	60	506	403	294	195	160				
		90	368	288	218	170	147				
4		30	909	835	730	506	323				
	C	60	765	692	589	390	269				
		90	621	550	454	301	228				
		30	1,149	1,061	941	712	525	374	322		
	A and B	60	915	832	728	546	432	343	312		
		90	692	619	536	426	374	322	302		
2		30	1,508	1,440	1,368	1,175	957	694	432		
	C	60	1,274	1,206	1,139	957	764	520	411		
		90	1,040	978	910	759	614	458	399		
		30	1,439	1,360	1,195	1,030	772	574	482	449	
	A and B	60	1,142	1,069	983	785	653	515	462	442	
		90	858	799	726	614	541	475	442	429	
1		30	1,960	1,802	1,729	1,551	1,340	917	673	574	535
	C	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
		30	1,884	1,801	1,710	1,519	1,278	938	764	681	647
	A and B	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
0		30	2,407	2,349	2,274	2,117	1,926	1,519	1,096	896	805
	C	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
		30	2,352	2,258	2,195	1,985	1,775	1,386	1,124	998	935
	A and B	60	1,869	1,806	1,733	1,565	1,418	1,187	1,008	986	924
		90	1,418	1,365	1,323	1,197	1,145	1,019	966	935	914
00		30	2,972	2,908	2,867	2,772	2,631	2,111	1,628	1,323	1,176
	C	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
		30	3,752	3,685	3,602	3,420	3,220	2,805	2,407	2,125	1,942
	A and B	60	2,988	2,955	2,888	2,755	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
0000		30	4,665	4,631	4,598	4,465	4,233	3,868	3,503	2,988	2,490
	C	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.							
		30	114	63	50				
8	C	60	86	57	47				
		90	66	50	44				
		30	194	116	101				
	A and B	60	138	100	85				
		90	107	89	79				
6		30	408	272	169	132			
	C	60	315	209	138	115			
		90	240	158	119	107			
		30	554	411	301	225	195		
	A and B	60	414	310	238	197	178		
		90	301	231	195	174	168		
4		30	840	738	602	476	362		
	C	60	692	592	481	375	300		
		90	551	465	365	297	251		
		30	1,044	932	786	660	559	443	386
	A and B	60	810	716	592	517	459	402	355
		90	608	538	467	420	391	363	334
2		30	1,391	1,318	1,198	1,093	978	739	590
	C	60	1,160	1,083	976	870	783	618	522
		90	928	875	776	694	629	522	470
		30	1,327	1,217	1,090	964	845	678	586
	A and B	60	1,038	953	845	744	682	573	527
		90	773	694	642	600	557	511	485
1		30	1,749	1,660	1,562	1,454	1,356	1,097	917
	C	60	1,454	1,363	1,294	1,198	1,087	888	780
		90	1,160	1,090	1,022	930	882	753	685
		30	1,686	1,566	1,488	1,322	1,201	996	871
	A and B	60	1,325	1,230	1,148	1,053	974	858	767
		90	979	900	880	812	783	730	704
0		30	2,180	2,098	1,990	1,920	1,807	1,575	1,334
	C	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
		30	2,108	1,977	1,883	1,754	1,657	1,404	1,252
	A and B	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
00		30	2,709	2,609	2,490	2,425	2,295	2,081	1,872
	C	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
		30	3,130	3,021	2,957	2,858	2,715	2,508	2,309
	A and B	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
0000		30	3,969	3,918	3,842	3,751	3,679	3,461	3,252
	C	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.					
		30	58	54	49	----------	----------
6	C	60	54	51	49	----------	----------
		90	49	47	48	----------	----------
		30	109	98	91	----------	----------
	A and B	60	96	90	88	----------	----------
		90	88	85	81	----------	----------
4		30	171	137	121	----------	----------
	C	60	138	121	112	----------	----------
		90	116	109	103	----------	----------
		30	324	269	235	224	219
	A and B	60	248	224	209	209	206
		90	201	198	193	196	196
2		30	543	433	349	308	287
	C	60	391	329	290	274	261
		90	276	266	253	248	248
		30	491	416	367	334	324
	A and B	60	360	328	318	301	295
		90	278	282	285	278	275
1		30	810	682	576	485	442
	C	60	580	507	449	416	393
		90	406	383	376	354	350
		30	783	663	588	534	506
	A and B	60	551	497	485	456	456
		90	414	414	414	414	431
0		30	1,156	1,024	892	787	713
	C	60	824	746	680	630	605
		90	592	568	551	538	526
		30	1,080	991	898	798	757
	A and B	60	772	731	699	673	662
		90	548	574	584	579	584
00		30	1,539	1,424	1,304	1,190	1,085
	C	60	1,120	1,043	976	944	887
		90	782	772	778	761	757
		30	2,001	1,876	1,768	1,634	1,618
	A and B	60	1,410	1,353	1,360	1,319	1,303
		90	1,020	1,020	1,062	1,070	1,136
0000		30	2,622	2,522	2,422	2,273	2,233
	C	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.									
		30	260	130	89	----------	----------	----------	----------	----------	----------
8	C	60	165	99	79	----------	----------	----------	----------	----------	----------
		90	110	83	70	----------	----------	----------	----------	----------	----------
		30	320	190	135	----------	----------	----------	----------	----------	----------
	A and B	60	200	140	120	----------	----------	----------	----------	----------	----------
		90	135	115	105	----------	----------	----------	----------	----------	----------
6		30	580	450	300	210	170	140	125	115	110
	C	60	430	300	220	170	150	130	120	110	110
		90	280	210	160	145	130	125	115	110	110
		30	640	480	360	280	240	200	185	175	165
	A and B	60	430	330	260	230	210	185	180	170	165
		90	270	230	210	195	185	175	170	165	165
4		30	970	850	710	560	450	310	260	220	210
	C	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.								
		30	440	260	200	160	150	145	140	----------
6	C	60	330	220	185	155	150	145	140	----------
		90	250	190	170	150	145	140	140	----------
		30	530	350	280	240	220	210	210	----------
	A and B	60	400	290	260	230	220	210	210	----------
		90	310	260	240	220	210	210	200	----------
4		30	1,000	730	520	340	300	270	270	260
	C	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.								
		30	1,730	1,590	1,420	960	560	400	330	250
6	C	60	1,570	1,430	1,260	810	480	380	320	250
		90	1,400	1,260	1,100	680	420	350	300	250
		30	1,970	1,800	1,590	1,110	710	540	470	390
	A and B	60	1,730	1,570	1,370	930	620	500	440	380
		90	1,500	1,340	1,160	770	550	460	420	370
4		30	2,560	2,430	2,280	1,940	1,500	1,070	790	520
	C	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.									
	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
¼		30	770	630	480	350	260	195	170	150	145
	C	60	610	500	370	270	220	180	160	150	140
		90	470	360	270	220	190	165	155	145	135
		30	1,140	1,010	880	740	610	450	390	340	330
	A and B	60	900	780	670	560	490	400	360	330	320
		90	670	580	500	450	410	360	340	320	320
5/16		30	1,550	1,440	1,330	1,210	1,090	820	620	480	420
	C	60	1,290	1,190	1,100	990	880	680	550	450	410
		90	1,040	960	870	780	690	550	480	420	390
		30	1,680	1,580	1,460	1,320	1,180	920	780	640	580
	A and B	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
3/8		30	2,200	2,130	2,030	1,920	1,800	1,530	1,280	940	800
	C	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
		30	2,570	2,480	2,370	2,260	2,140	1,870	1,630	1,320	1,180
	A and B	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
7/16		30	3,280	3,210	3,130	3,040	2,940	2,700	2,450	1,990	1,690
	C	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
		30	3,120	3,020	2,930	2,830	2,720	2,470	2,200	1,790	1,600
	A and B	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
½		30	3,970	3,900	3,830	3,740	3,640	3,420	3,180	2,720	2,320
	C	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
		30	4,210	4,150	4,070	3,960	3,840	3,600	3,380	2,930	2,620
	A and B	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
9/16		30	5,310	5,280	5,230	5,140	5,050	4,840	4,590	4,140	3,720
	C	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
		30	5,250	5,160	5,070	4,980	4,880	4,660	4,390	3,960	3,590
	A and B	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
5/8		30	6,550	6,500	6,440	6,370	6,280	6,100	5,860	5,410	4,970
	C	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 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	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		30	1,790	1,520	1,270	870	650	570	530	480
	C	60	1,530	1,290	1,080	760	610	550	520	470
		90	1,300	1,070	980	680	570	520	500	460
		30	1,940	1,700	1,450	1,070	870	770	730	680
	A and B	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		30	2,690	2,480	2,250	1,750	1,360	1,110	1,010	870
	C	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
		30	3,140	2,910	2,660	2,220	1,840	1,600	1,470	1,340
	A and B	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		30	4,090	3,920	3,740	3,260	2,790	2,400	2,120	1,730
	C	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
		30	3,910	3,660	3,390	2,930	2,540	2,240	2,040	1,790
	A and B	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
½		30	4,950	4,800	4,600	4,150	3,660	3,260	2,890	2,370
	C	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
		30	5,320	5,120	4,920	4,470	4,040	3,630	3,320	2,920
	A and B	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		30	6,750	6,600	6,410	6,010	5,590	5,100	4,670	3,880
	C	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
		30	6,630	6,460	6,230	5,770	5,340	4,940	4,570	4,030
	A and B	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		30	8,340	8,190	8,030	7,660	7,250	6,800	6,320	5,330
	C	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
5/16	A and B	°F. 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
	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
3/8	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
	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
7/16	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
	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
1/2	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
	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	5,860
9/16	A and B	30	9,300	9,230	9,150	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
	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
5/8	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
	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
6	A and B	°F. 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
5/16	A and B	°F. 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
1	A and B	°F. 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	495	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.								
		32	170	210	110	------	------	------	------	------
	A and B	60	120	190	100	80	------	------	------	------
		120	100	110	90	60	------	------	------	------
4		32	170	220	290	130	------	------	------	------
	C	60	120	190	230	120	------	------	------	------
		120	100	130	160	100	------	------	------	------
		32	260	350	440	210	180	------	------	------
	A and B	60	210	290	370	190	170	------	------	------
		120	150	200	210	170	150	------	------	------
2		32	260	370	470	530	280	------	------	------
	C	60	210	300	390	400	250	------	------	------
		120	150	150	260	300	120	------	------	------
		32	320	440	580	400	280	230	------	------
	A and B	60	290	370	470	330	250	220	------	------
		120	200	250	300	280	220	210	------	------
1		32	320	460	600	840	550	400	------	------
	C	60	290	380	490	700	490	380	------	------
		120	200	200	310	430	400	330	------	------
		32	500	580	700	800	490	390	------	------
	A and B	60	330	450	580	620	420	330	------	------
		120	250	300	380	440	380	320	------	------
0		32	500	590	730	1,080	1,000	630	500	------
	C	60	330	480	610	900	800	580	490	------
		120	250	320	400	550	600	510	450	------
		32	510	700	890	1,250	880	620	520	------
	A and B	60	410	580	710	1,010	700	580	500	------
		120	300	390	470	610	540	500	480	------
00		32	510	720	920	1,320	1,650	1,200	890	------
	C	60	410	600	780	1,120	1,310	970	780	------
		120	300	400	500	700	890	780	700	------
		32	640	880	1,110	1,590	1,390	1,020	830	------
	A and B	60	520	710	900	1,290	1,090	880	790	------
		120	400	500	590	780	790	720	700	------
000		32	640	900	1,170	1,700	2,200	1,820	1,420	1,160
	C	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
		32	820	1,110	1,410	2,000	2,080	1,650	1,370	1,200
	A and B	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
0000		32	820	1,140	1,490	1,130	1,800	1,750	1,300	940
	C	60	680	950	1,230	1,800	2,350	2,300	1,920	1,640
		120	500	500	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 81.

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
	Inches		Sq. In.	Pounds	Pounds
Circular mills.					
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	.0280	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, 15,000,000 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.
3/4 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
	11/32	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
0000	----------	7x	.166	20,940
	1/2	7 No. 6	.144	18,200
000	----------	7x	.132	16,600
	7/16	7 No. 7	.114	14,420
00	----------	7x	.105	13,160
	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
	Inches	Sq. In.		c. m.	Pounds	Pounds
Circular mills.						
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	.4620	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.

Note: Sags in Table 47, page 163, and tensions in Table 61, page 173, were supplied by the Aluminum Co. of America. The breaking load of the cables was 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
Bare solid copper.	Inch	Lbs./Ft.	Lbs./Ft.
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 Conductor	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.			
¼ inch	.250	.586	.119
5/16 inch	.312	.711	.205
⅜ inch	.375	.826	.282
7/16 inch	.437	.991	.408
½ inch	.500	1.111	.489
9/16 inch	.562	1.312	.652
⅝ 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
⅜ inch	.384	.882	.332
7/16 inch	.432	.998	.418
½ 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	3.293
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	.880	.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. mils—				
250,000	1.241	0.862	2.213	1.309
350,000	1.319	.978	2.620	1.663
500,000	1.406	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.				
¼ inch	.833	.250	1.018	.277
5/16 inch	.875	.312	1.126	.374
⅜ inch	.917	.375	1.234	.469
7/16 inch	.958	.437	1.379	.598
½ inch	1.000	.500	1.495	.699
9/16 inch	1.042	.562	1.675	.861
⅝ 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
⅜ inch	.923	.384	1.276	.508
7/16 inch	.955	.432	1.381	.601
½ 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 21 (Order 1261 A, 4) for poles when installed. Table 74 gives the values for dense southern yellow pine; Table 75 for other pine, chestnut, western cedar, cypress, etc., having a recognized ultimate fiber stress of 5,000 pounds per square inch; and Table 76 for woods having an ultimate fiber stress of 3,600 pounds per square inch, such as redwood and eastern cedar (northern white cedar).

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 following formula has been used in calculating the moments:

$M = 0.0002638\ f\ C^3$ = moment in pound-feet; where
f = allowable fiber stress in pounds per square inch, and
C = 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.

TABLE 74

Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 6,500 Pounds per Square Inch (Dense Southern Yellow Pine)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)					
	2,170	2,600	3,250	3,900	4,870	6,500
	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.
24	7,900	9,500	11,850	14,200	17,750	23,700
25	8,950	10,700	13,400	16,100	20,050	26,800
26	10,050	12,050	15,050	18,100	22,600	30,150
27	11,250	13,500	16,900	20,250	25,300	33,750
28	12,550	15,050	18,800	22,600	28,200	37,650
29	13,950	16,750	20,900	25,100	31,350	41,800
30	15,450	18,500	23,150	27,800	34,700	46,300
31	17,050	20,450	25,550	30,650	38,250	51,100
32	18,750	22,500	28,100	33,700	42,100	56,200
33	20,550	24,650	30,800	36,950	46,150	61,600
34	22,500	26,950	33,700	40,450	50,500	67,400
35	24,550	29,400	36,750	44,100	55,100	73,500
36	26,700	32,000	40,000	48,000	59,950	80,000
37	29,000	34,750	43,400	52,100	65,050	86,850
38	31,400	37,650	47,050	56,450	70,500	94,100
39	33,950	40,700	50,850	61,050	76,200	101,700
40	36,650	43,900	54,850	65,850	82,200	109,750
41	39,450	47,250	59,100	70,900	88,550	118,200
42	42,400	50,800	63,500	76,200	95,200	127,050
43	45,500	54,550	68,150	81,800	102,150	136,350
44	48,750	58,450	73,050	87,650	109,450	146,050
45	52,150	62,500	78,150	93,750	117,050	156,250
46	55,700	66,750	83,450	100,150	125,050	166,900
47	59,450	71,200	89,000	106,800	133,400	178,000
48	63,300	75,850	94,800	113,800	142,100	189,650
49	67,350	80,700	100,850	121,050	151,150	201,750
50	71,550	85,750	107,150	128,600	160,600	214,350
51	75,950	91,000	113,750	136,450	170,400	227,450
52	80,500	96,450	120,550	144,650	180,650	241,100
53	85,200	102,100	127,650	153,150	191,250	255,300
54	90,150	108,000	135,000	162,000	202,300	270,000
55	95,250	114,100	142,650	171,150	213,750	285,300
56	100,550	120,450	150,550	180,700	225,600	301,150
57	106,000	127,000	158,800	190,550	237,900	317,550
58	111,700	133,800	167,300	200,750	250,650	334,550
59	117,550	140,850	176,100	211,300	263,850	352,150
60	123,650	148,150	185,200	222,200	277,500	370,400
61	129,950	155,700	194,600	233,500	291,600	389,200
62	136,450	163,450	204,350	245,200	306,200	408,650
63	143,150	171,500	214,400	257,250	321,250	428,750
64	150,050	179,800	224,750	269,700	336,800	449,500
65	157,200	188,350	235,450	282,550	352,800	470,900
66	164,600	197,200	246,500	295,800	369,350	492,950
67	172,150	206,300	257,850	309,450	386,400	515,700
68	180,000	215,050	269,600	323,500	403,950	539,150
69	188,050	225,300	281,650	338,000	422,050	563,300
70	196,350	235,250	294,050	352,900	440,650	588,150
71	204,900	245,500	306,850	368,250	459,800	613,700
72	213,650	256,000	320,000	384,000	479,500	640,000
73	222,700	266,800	335,500	400,250	499,750	667,050
74	231,950	277,950	347,400	416,900	520,600	694,850
75	241,500	289,350	361,700	434,050	542,000	723,400

TABLE 75

Resisting Moments for Poles of Woods With Ultimate Fiber Stress of 5,000 Pounds per Square Inch (Pine, Chestnut, Western Cedar, Cypress, etc.)

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
	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.
24	4,550	6,100	7,300	9,100	10,950	13,700	18,250
25	5,150	6,900	8,250	10,300	12,350	15,450	20,600
26	5,800	7,750	9,250	11,600	13,900	17,400	23,200
27	6,500	8,650	10,400	13,000	15,600	19,450	25,950
28	7,250	9,650	11,600	14,500	17,350	21,700	28,950
29	8,050	10,750	12,850	16,100	19,300	24,150	32,150
30	8,900	11,900	14,250	17,800	21,350	26,700	35,600
31	9,800	13,100	15,700	19,650	23,600	29,450	39,300
32	10,800	14,450	17,300	21,600	25,950	32,400	43,200
33	11,850	15,850	18,950	23,700	28,450	35,550	47,400
34	12,950	17,300	20,750	25,900	31,100	38,900	51,850
35	14,150	18,900	22,600	28,300	33,950	42,400	56,550
36	15,400	20,550	24,600	30,750	36,900	46,150	61,550
37	16,700	22,300	26,700	33,400	40,100	50,100	66,800
38	18,100	24,150	28,950	36,200	43,450	54,300	72,400
39	19,550	26,150	31,300	39,100	46,950	58,700	78,250
40	21,100	28,200	33,750	42,200	50,650	63,300	84,400
41	22,750	30,350	36,350	45,450	54,550	68,200	90,900
42	24,450	32,650	39,100	48,850	58,650	73,300	97,700
43	26,200	35,050	41,950	52,450	62,900	78,650	104,850
44	28,100	37,550	44,950	56,200	67,400	84,250	112,350
45	30,050	40,150	48,100	60,100	72,100	90,150	120,200
46	32,100	42,900	51,350	64,200	77,050	96,300	128,400
47	34,250	45,750	54,800	68,500	82,150	102,700	136,950
48	36,450	48,700	58,350	72,950	87,500	109,400	145,850
49	38,800	51,850	62,050	77,600	93,100	116,400	155,200
50	41,200	55,050	65,950	82,450	98,900	123,650	164,900
51	43,750	58,450	70,000	87,500	105,000	132,200	174,950
52	46,350	61,950	74,200	92,750	111,300	139,100	185,450
53	49,100	65,600	78,550	98,200	117,800	147,300	196,350
54	51,900	69,350	83,100	103,850	124,600	155,750	207,700
55	54,850	73,300	87,800	109,700	131,650	164,600	219,450
56	57,900	77,350	92,650	115,800	139,000	173,750	231,650
57	61,050	81,600	97,700	122,150	146,550	183,200	244,250
58	64,350	85,950	102,950	128,700	154,400	193,000	257,350
59	67,700	90,500	108,350	135,450	162,550	203,150	270,900
60	71,250	95,150	113,900	142,450	170,950	213,700	284,900
61	74,850	100,000	119,750	149,700	179,650	224,550	299,400
62	78,600	104,500	125,750	157,200	188,600	235,750	314,350
63	82,450	110,150	131,900	164,900	197,900	247,350	329,800
64	86,450	115,500	138,300	172,900	207,450	259,350	345,750
65	90,550	121,000	144,900	181,100	217,350	271,650	362,250
66	94,800	126,650	151,700	189,600	227,500	284,400	379,200
67	99,200	132,500	158,700	198,350	238,000	297,550	396,700
68	103,700	138,500	165,900	207,350	248,850	311,050	414,750
69	108,350	144,700	173,300	216,650	260,000	325,000	433,300
70	113,100	151,100	180,950	226,200	271,450	339,300	452,400
71	118,000	157,700	188,850	236,050	283,250	354,050	472,100
72	123,100	164,450	196,950	246,150	295,400	369,250	492,300
73	128,250	171,400	205,250	256,550	307,850	384,850	513,100
74	133,600	178,500	213,800	267,250	320,700	400,850	534,500
75	139,100	185,850	222,600	278,250	333,850	417,300	556,450

TABLE 76

Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 3,600 Pounds per Square Inch (Eastern Cedar, Redwood, etc.)

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
	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.	Lb.—ft.
24	3,300	4,400	5,250	6,550	7,900	9,850	13,150
25	3,700	4,950	5,950	7,400	8,900	11,150	14,850
26	4,150	5,550	6,700	8,350	10,000	12,500	16,700
27	4,650	6,250	7,500	9,350	11,200	14,000	18,700
28	5,200	6,950	8,350	10,400	12,500	15,650	20,850
29	5,800	7,700	9,250	11,600	13,900	17,350	23,150
30	6,400	8,550	10,250	12,800	15,400	19,250	25,650
31	7,050	9,450	11,300	14,150	17,000	21,200	28,300
32	7,800	10,350	12,450	15,550	18,650	23,350	31,100
33	8,550	11,400	13,650	17,050	20,500	25,600	34,150
34	9,350	12,450	14,950	18,650	22,400	28,000	37,350
35	10,200	13,550	16,300	20,350	24,450	30,550	40,700
36	11,100	14,750	17,700	22,150	26,600	33,250	44,300
37	12,050	16,050	19,250	24,050	28,850	36,100	48,100
38	13,050	17,350	20,850	26,050	31,250	39,100	52,100
39	14,100	18,800	22,550	28,150	33,800	42,250	56,350
40	15,200	20,250	24,300	30,400	36,450	45,600	60,800
41	16,350	21,800	26,200	32,750	39,250	49,100	65,450
42	17,600	23,450	28,150	35,200	42,200	52,750	70,350
43	18,900	25,150	30,200	37,750	45,300	56,650	75,500
44	20,200	26,950	32,350	40,450	48,550	60,650	80,900
45	21,650	28,850	34,600	43,250	51,900	64,900	86,550
46	23,100	30,800	37,000	46,200	55,450	69,350	92,450
47	24,650	32,850	39,450	49,300	59,150	73,950	98,600
48	26,250	35,000	42,000	52,500	63,000	78,750	105,050
49	27,950	37,250	44,700	55,850	67,050	83,800	111,750
50	29,700	39,550	47,500	59,350	71,250	89,050	118,700
51	31,500	42,000	50,400	63,000	75,600	94,500	126,000
52	33,400	44,500	53,400	66,750	80,100	100,150	133,550
53	35,350	47,150	56,550	70,700	84,850	105,050	141,400
54	37,400	49,850	59,800	74,750	89,700	112,150	149,550
55	39,500	52,650	63,200	79,000	94,800	118,500	158,000
56	41,700	55,600	66,700	83,400	100,050	125,100	166,800
57	43,950	58,600	70,350	87,950	105,500	131,900	175,850
58	46,300	61,750	74,100	92,650	111,200	138,950	185,300
59	48,750	65,000	78,000	97,500	117,500	146,300	195,050
60	51,300	68,400	82,050	102,550	123,100	153,850	205,150
61	53,900	71,850	86,200	107,800	129,350	161,650	215,550
62	56,600	75,450	90,550	113,150	135,800	169,750	226,350
63	59,350	79,150	95,000	118,750	142,500	178,100	237,450
64	62,250	83,000	99,600	124,500	149,350	186,700	248,950
65	65,200	86,950	104,300	130,400	156,900	195,600	260,800
66	68,250	91,000	109,200	136,500	163,800	204,750	273,050
67	71,400	95,200	114,250	142,800	171,400	214,200	285,650
68	74,650	99,550	119,450	149,300	179,150	223,950	298,600
69	78,000	104,000	124,800	156,000	187,200	234,000	312,000
70	81,450	108,600	130,300	162,850	195,450	244,300	325,750
71	85,000	113,300	135,950	169,950	203,950	255,000	339,900
72	88,600	118,150	141,800	177,250	212,700	265,850	354,450
73	92,350	123,150	147,800	184,700	221,650	277,100	369,450
74	96,200	128,300	153,950	192,400	230,900	288,600	384,850
75	100,150	133,550	160,250	200,300	240,400	300,500	400,650

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 25 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 77 gives the minimum permissible depreciated ground-line circumference for poles which have just met the requirements when installed. Table 79 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 78 shows the situations to which the various values in Tables 77 and 79 apply.

TABLE 77

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—					
	⅔	3/5	5/9	½	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 77

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 78

Allowable Depreciation of Wood Poles Under Vertical and Transverse Loading for Various Situations

(This table locates the situations to which the columns of Tables 77 and 79 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	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	1/2	2/5
Elsewhere than at crossings.		
Grade A	2/3	5/9
Grade B	3/5	1/2
Grade C	1/2	1/2

TABLE 79

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—					
	2/3	3/5	5/9	1/2	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

Allowable Number of Wires on a Given Pole With and Without Side Guys

Table 80 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 81 and 82 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 80

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, Chestnut, Western Cedar, 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 81

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 82

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	79	97
	100	12	18	30	48	61	63	78
	125	9	14	24	39	48	53	65
	150	8	12	20	32	40		

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 83 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 83

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

Appendix F—Definition of American Society for Testing Materials of Dense Southern Yellow Pine

This term includes the species of yellow pine growing in the Southern States from Virginia to Texas; that is, the pines hitherto known as long-leaf pine (Pinus palustris), short-leaf pine (Pinus echinata), loblolly pine (Pinus taeda), Cuban pine (Pinus heterophylla) and pond pine (Pinus serotina).

Under this heading two classes of timber are designated: (a) Dense southern yellow pine and (b) sound southern yellow pine. It is understood that these two terms are descriptive of quality rather than of botanical species.

(a) Dense southern yellow pine shall show on either end an average of at least six annual rings per inch and at least one-third summer wood, or else the greater number of the rings shall show at least one-third summer wood, all as measured over the third, fourth, and fifth inches on a radial line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided that the amount of summer wood as above measured shall be at least one-half.

The contrast in color between summer wood and spring wood shall be sharp and the summer wood shall be dark in color, except in pieces having considerably above the minimum requirement for summer wood.

(b) Sound southern yellow pine shall include pieces of southern pine without any ring or summer-wood requirement.

Appendix F, page 195, is no longer a necessary supplement to the corrected Tables 19 and 20 in the Errata included in the first printing.

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, Section 130–139, inclusive, apply to all electrical utilization equipment, operating at voltages between 25 and 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 Part 5.

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.

(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 enclosed 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 150 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 ac-

cordance with section 130.9 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 enclosure 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 fire proof construction, shall be guarded by enclosure 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. 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 enclosure 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 currents above 30 amperes, lugs into which the connecting wires may be soldered, or approved solderless connectors, shall be provided. For currents of 30 amperes or less the parts to which wiring connections are made 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 jointed as to be mechanically and electrically secure without solder. The joints shall then be soldered, unless made with an approved splicing device, and shall be covered with an insulation equal to that on the wires.

c. Stranded wires, other than those used in flexible cords, shall be soldered together before being fastened 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 a system to which are connected trolley wires with a ground return shall not be used in buildings and should not be used elsewhere.

Note: Electric railway cars, electric car houses, power houses, passenger and freight stations connected with the operation of electric railways are exempted from this order.

b. In car houses and similar locations where service at low voltage is not available and where necessary to use low voltage pendant 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 enclose and protect other equipment, the adequacy of the protection thus provided.
3. Electrical insulation.
4. Heating effects under normal conditions of use and also under abnormal conditions liable to arise in service.
5. Arcing effects.

b. Bases for the mounting of live parts shall be composed of approved non-combustible, non-absorptive insulating material, and the design shall be 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 cut-out bases shall be kept outside the area included by the outside edges of the fuse terminals. Nuts or screw heads on the under side of the base shall be countersunk and sealed with a waterproof compound.

c. The set-screw form of contact shall not be used.

d. All devices provided with terminals for the attach-

ment 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 devices having a normal current rating of over 30 amperes need not be marked for identification.

f. The terminals of utilization devices need not be marked to indicate the proper connection to the grounded conductor. If the terminals on utilization devices, including single-pole switches are marked, the switch shall not be placed in the identified side of the circuit.

g. The terminals of portable devices 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 in 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 1 of this section. The other terminals need not be marked for identification.

k. In the case of devices with Edison 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 finish of the braid on 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, trade-mark or other identification symbol shall be placed on fittings and materials, together with such other markings giving voltage, current, wattage or other appropriate ratings as are prescribed elsewhere in this code.

SECTION 130.3. OUTSIDE SUPPLY CONDUCTORS

Order 1303.06. Yard Wiring.

For wiring and lamps on series circuits of constant current systems, see order 1350.01.

a. All wiring on exterior of building walls shall comply with the requirements for services in order 1304.03. For circuits exceeding 600 volts, it shall be in rigid steel conduit or metal sheathed cable.

b. Conduit work on the exterior of buildings shall be weather-proof and shall comply with the requirements of Section 130.5, for interior conduit work.

c. Open wires on exterior of building walls shall be kept at least 6 inches from conductors of other supply or signal circuits not in conduit.

d. Wires strung above alleys, driveways and other open spaces shall have a clearance above ground as required by Order 1220–a Table 3 of Part 2.

Order 1303.07. Festoon Lighting.

a. Supply shall be taken only from such points on the wiring system so that correct fusing can be provided for. Conductors shall be protected by fuses not larger than the values given in Column C of Table 1, Order 1306.12.

b. The conductors of festoon streamers shall not be smaller than No. 14, and shall have an approved rubber covering. When the span of any string of lamps exceeds 40 feet the string shall be supported by a suitable messenger wire substantially fastened at each end.

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 se-

cure, 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. The wiring in any building or group of buildings, including the service connections thereto, shall be so arranged as not to serve as a shunt around any street fuse or switch.

b. 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 2 inches of concrete beneath a building, or buried in 2 inches of brick or concrete within a wall shall be considered outside the building.

c. No building shall be supplied from the same exterior distribution system through more than one set of service conductors, unless a separate service is required for fire pumps, or for emergency lights, as required by order 1339.02 or unless capacity or emergency requirements make multiple services desirable, or unless there are different transformers or sets of multiphase transformers.

d. If supplied by more than one set of service leads at the same side of a building, the service equipments shall be grouped (except for firepump service, which may be isolated) and the type of service separately indicated.

Note: Switches or other control equipment must be plainly marked as to type of service, voltage, etc.

Order 1304.02. Overhead, From Main to Building.

a. Approved weatherproof or approved rubber covering shall be employed on single wires, and approved rubber covering on multiple-conductor cables. 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 a service from overhead supply wires to a building is carried underground, the portion of the wires underground and running up the pole to a point at least 8 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 shall be kept at least 6 inches from adjacent woodwork and at least 12 inches from over-hanging projections of combustible material, unless fittings approved for the purpose are used.

Order 1304.03. On Exterior of Building.

a. Wires or cables which are liable to contact with awnings, swinging signs, shutters, or other movable objects, shall be enclosed in approved rigid steel conduit. All conduit systems on exterior of buildings shall be made weatherproof.

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 shall not be within 8 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 metal sheath or 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 covering for multiple-conductor cables.

e. Rigid steel conduit systems made weatherproof shall be used for wiring on exterior of buildings where open wiring cannot readily comply with the above requirements and

may be used in lieu of such open wiring under any conditions.

Order 1304.04. Entrance.

a. All service wires shall enter the building at a point as near as practicable to the location of the service switch. Service conductors may be run through but shall not be run within a building wall unless in conduit embedded in brick, tile, concrete, or other fire resistive construction, or unless protected by fuses at the outer end of the service conduit.

b. Wires entering building shall be rubber-covered from the point of support on the outside of the building nearest the entrance to the building. The service wires shall be not smaller than No. 8. In addition, underground service conductors shall be protected from moisture by a covering of lead or 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 cable, or other approved means.

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. Overhead wires shall enter buildings only in rigid steel conduit 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, directly into the service cabinet. Where rigid steel conduit is used it shall have weatherproof threaded or threadless joints and be equipped with approved service-head.

Note: Where service switch is inside building, it is recommended that conductors entering the building from overhead lines be encased in approved rigid metal conduit.

d. Where a conduit 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. All combustible material shall be kept from the immediate vicinity.

e. Where conduit is used to contain service conductors, the inner end of the service conduit shall enter a terminal box or service switch cabinet or be made up directly to an equivalent device, enclosing all live metal parts, and shall be electrically connected to the box or equivalent device,

unless isolated from conducting surfaces and unexposed to contact by persons or materials which may be in contact also with other conducting surfaces, including the terminal box or equivalent device.

f. Service conduit shall be grounded unless isolated from grounded surfaces, and unexposed to contact by persons or materials which may be in contact with other conducting surfaces, and containing no wire of more than 150 volts to ground and no wire of an ungrounded circuit exposed to or connected to other circuits of more than 150 volts to ground. Conduit and metal pipe if not electrically connected to an interior conduit system shall be considered sufficiently grounded if containing lead-sheathed cable bonded to a continuous underground lead-sheathed cable system.

It is sometimes advisable to insulate interior conduit or sheathing from service conduit or sheathing to prevent burnouts of small interior conduit, armored cable sheaths, or metal moulding by large currents which might flow from exterior conduit to interior conduit and water pipes.

Order 1304.05. Service Equipment.

a. In this order the word "switch" shall be construed as including a circuit-breaker that is capable of manual operation.

b. A service switch shall be provided for each set of service conductors and shall indicate plainly whether it is open or closed. The switch or switches shall be placed at the nearest readily accessible point to the entrance of the service, either inside or outside the building wall and shall be of a type approved for the prevailing conditions such as exposure to the weather. This switch shall be installed in one of the following ways:

1. As an air-break or oil-immersed switch enclosed in a metal case;

2. As an air-break or oil-immersed switch mounted on a switchboard or panelboard which is accessible to qualified persons only.

c. A service switch shall simultaneously interrupt all conductors of the circuit in which it is inserted and disconnect the meter and overload protective devices, except that

1. Where the switch, fuses, and meter are combined in an approved device or compact combination of such devices having no live parts or wiring exposed, and capable of being sealed or locked, the switch may be so connected that it will not disconnect the fuses or the meter from the sup-

ply line; and the potential coils of the meter may be connected on the supply side of the service cutout.

2. Where the switch and fuses are mounted in an approved cabinet having no live parts or wiring exposed and capable of being sealed or locked, the switch blade may be omitted in any grounded conductor of a direct-current or single-phase circuit or any grounded neutral if other approved means is provided within the cabinet for disconnecting such conductor.

3. Where a service switch is mounted on a switchboard, the switch blade in the grounded conductor may be omitted if other approved means is provided on the switchboard to disconnect the grounded conductor.

4. In buildings served through 2, 3 or 4 meters from a single set of service conductors not exceeding 150 volts to ground, the service conductors may be run to a separate switch and cutout for each meter if grouped at the point of entrance. The service run shall be continuous to the last service switch and cutout or to the bus on a switchboard, but taps may be made to the individual service switches. In installations involving more than 4 meters the entire current shall be taken through one main entrance switch.

5. 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.

Supplement 3

d. A service switch shall be enclosed and externally operable unless made inaccessible to other than qualified persons. A service switch shall be readily accessible and externally operable unless additional switches are provided for control of all individual feeders and circuits supplied through it, as recommended below.

Note: 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 enclosed and the switch being externally operable. The location of this switch and cutout may, or may not, be close to the meter.

e. The service switch shall have sufficient capacity to rupture a current equal to the capacity of the cutout base or to the rating of other type of protective device in series with it.

Supplement

f. Each ungrounded service conductor shall be protected by a fuse or automatic overload circuit-breaker arranged to cut off the current from all circuits fed through it, and from all devices, in such circuits other than the service switch, and under the conditions specified in paragraph (c) 1, of this section, the meter. Fuses, where used, shall be controlled by the service switch except where they are located at the outer end of the service conduit or as specified in paragraph (c) 1, of this section. A circuit-breaker, where used, shall be controlled by the service switch unless it is manually operable.

g. When the service fuses are locked or sealed or are located at the outer end of the service conduit, branch fuses connected on load side of meter shall be accessible to persons concerned and shall be enclosed in an approved casing or cabinet. If the installation consists of a single branch circuit, fuses shall be inserted in series with the service fuses and shall be of smaller capacity. These fuses need not be at the meter, but shall be accessible.

h. No fuse or automatic overload circuit-breaker shall be placed in a grounded service wire except a circuit-breaker which simultaneously opens all conductors of the circuit.

i. Where not located on a switchboard or panelboard, accessible only to qualified persons, live parts of switches, buses, fuses, cutout bases, and automatic overload circuit-breakers shall be enclosed so that they will not be exposed to accidental contact. The enclosure shall be grounded in accordance with the method for equipment grounding given in the Introductory part of this Code.

Exception: Grounding may be omitted where enclosures are isolated from conducting surfaces and unexposed to contact by persons or materials that may be in contact with other conducting surfaces including other enclosures, 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.

j. A manually operable automatic overload circuit-breaker may be used in place of both service switch and fuse, and shall be of a type approved for this use.

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 automatic overload 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. This rule includes garages and similar outbuildings of residential installations.

l. When service wires carry a voltage exceeding 600 volts between conductors, the requirements of order 1350.09 of Section 135.0 of this Code shall apply.

Order 1304.06. Hazardous Locations.

a. Service entrance equipment shall not be placed in the class I locations defined in paragraph (b) of Order 1332.01 of Section 133.2 of this code. (See paragraph b Order 1332.03.)

b. When it is necessary to place service entrance equipment in the class II or class III location defined in paragraphs (c) and (d) respectively of Order 1332.01, the provisions of paragraph (b) Order 1332.04, and paragraph (b), Order 1332.05, 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.

Order 1305.00. Polarity Identification of Systems and Circuits.

a. Except as otherwise permitted in paragraph c of this section, any interior wiring system shall have such an arrangement of conductors that systematic polarization, protective grounding, and connection to service may be readily accomplished, as in the following recognized systems and circuits.

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 system, Edison three wire direct current, or three wire single phase alternating current, the neutral wire of which is continuously identified.
3. A multi-wire system (more than two wires, but not including an Edison three wire system), one wire of which is continuously identified.

b. 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.

c. Interior wiring systems or circuits of other than the above types such as two wire or multi-wire systems or circuits in which it is not intended to use a continuously identified and grounded wire, may be used as permitted by the authority enforcing this Code, as in the following recognized systems and circuits.

GROUNDED SYSTEMS AND CIRCUITS WITHOUT IDENTIFIED WIRE

1. A two-wire system or circuit supplied from the outside wires of an Edison three-wire system having a grounded neutral.
2. A multi-wire polyphase system or circuit with the neutral of one phase grounded.
3. A multi-wire polyphase system or circuit with the neutral wire grounded, but not used as a circuit conductor.

UNGROUNDED SYSTEMS AND CIRCUITS

1. Two-wire or multi-wire systems and circuits not intended to be grounded.

d. Every lighting and/or appliance branch circuit shall have one wire continuously identified, grounded and connected to each lamp or appliance on the circuit, except that two-wire branches tapped from the outside wires of a three-wire d. c. or single phase circuit within the same premises will be permitted if no fuse is omitted and no single pole switches or sockets are used.

Such an *identified* branch circuit may be supplied only by direct connection from the systems or circuits described in paragraph a, of this section.

e. Lighting and/or appliance branch circuits shall not be supplied from auto-transformers used as balance coils, except as provided in Order 1305.12.

f. In any of the above systems no continuously identified grounded wire and no unidentified grounded wire shall have placed in it a single pole switch, or an automatic cut-out, which operates to open that wire only.

g. Continuous identification of wires of an interior wiring system shall be accomplished for rubber covered wires of No. 6 gauge and less by the use of continuously identified outer covering as specified in paragraph f, Order 1306.02,

of Section 130.6 of this code. For larger wires and wires of other than rubber covering, the continuous identification shall be secured either as for the smaller rubber covered wires or, in process of installation by marking, and testing where necessary, all continuous lengths of wires used for that polarity for which identification is required.

h. Wires having white or natural gray covering shall not be used in identified systems or circuits except as conductors for which identification is required by this section.

The following methods of "wiring in" single-pole switches in circuits of armored cable or non-metallic sheathed cable, are suggested, as the ordinary two-wire cable having one wire identified is not permitted for single pole switch loops by the above.

1. The use of two-wire cable, if the identified wire is rendered permanently unidentified by painting, or other effective means at every point where outlets, switch boxes, junction boxes or pull boxes make the wires visible and accessible.
2. The use of a three-wire cable having one identified wire, which identified wire is cut off at each end of the section of cable where the wire emerges, or which is in some manner properly marked at each end to show that the identified wire of this cable is not in the circuit.
3. By so arranging the wiring that both conductors of the circuit coming from the distribution point pass through the switch box to the outlet.

i. 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 continuously identified as specified in paragraph f, of order 1306.09 of Section 130.6 of this code. This identified conductor of the cord shall 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 1305.01. Open Wires.

a. Single 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 7/8 inch in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring.

2. By a substantial running board 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 7/8 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 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.

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. Open wires in accessible attics or roof spaces, shall be installed as follows:

1. When run within five 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 within five feet of floor or joist, across the face of rafters or studding, or across the top or face of floor joists, wire shall be protected by substantial guard strips at least as high as the wire.

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 1/2 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	5/16	¼	⅜
8–4	1½	⅞	2	5/16	5/16	5/8
2–00	2	1	2¼	7/16	5/8	5/8
000–300,000 C. M.	2½	1⅛	2¾	7/16	11/32	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.
3/8	11/16	9/32	15/16	½
7/16	13/16	5/16	1 3/16	½
½	15/16	9/32	1 5/16	½
9/16	1 1/16	5/16	1 7/16	⅝
⅝	1 3/16	9/32	1 5/8	⅝
¾	1 7/16	7/32	1 15/16	⅝
1	1 11/16	9/32	2 5/16	⅝
1¼	1 15/16	11/32	2 11/16	¾
1½	2 3/16	11/32	3 1/16	¾
1¾	2 5/16	13/32	3 7/16	¾
2	2 5/16	13/32	3 7/16	¾
2¼	3 5/16	15/32	3 13/16	1
2½	3 11/16	15/32	4 3/16	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 3, 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, or approved nonmetallic sheathed cable shall be used.

g. Where a change is made from concealed work to conduit 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. The terminal fitting need not be accessible.

h. In installing wires the precautions as to rigid supporting, separation from wires of other circuits, clearance from foreign 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 paragraphs a and b of Order 1307.03 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 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 section.

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. The entire system shall be fastened so that it will remain securely 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 130.9 of this code.

l. Conduit wire shall be of approved rubber-covered type (Types R, RD, etc.) or, if in a permanently dry location, may be of the varnished-cambric insulated type (Type VC). A double braid shall be provided for conductors larger than No. 8 and for all twin, twisted or multiple-conductor cables. Slow-burning insulation (Type SB wire) may, however, be used in permanently dry and excessively hot locations by permission of the authority enforcing this code. All wires of No. 6 or larger shall be stranded. There shall be no splice or tap within the conduit proper. With flexible metallic conduit in wet or damp places wires shall have lead coverings (Type RL).

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.

n. Wires of different systems shall not occupy the same conduit.

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 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 a later date.

p. Except in the case of stage pocket and border circuits and flasher and carriage-call wires and elevator control wires or by permission of the authority enforcing this code, one conduit shall not contain more wires than as specified in Table 1 of this section.

q. Size of conduits for the Installation of Wires and Cables, 0–600 volts.

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	¾	¾	1	1	1	1
12	½	½	¾	¾	¾	1	1	1	1¼
10	½	¾	¾	1	1	1	1¼	1¼	1¼
8	½	¾	1	1	1	1¼	1¼	1¼	1¼
6	½	1	1¼	1¼	1½	1½	2	2	2
5	¾	1¼	1¼	1¼	1½	2	2	2	2
4	¾	1¼	1¼	1½	2	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1¼	1½	1½	2	2	2½	2½	2½
1	¾	1½	1½	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	1¼	2	2½	2½	3	3	3½	3½	4
200000 C. M.	1¼	2	2½	2½	3	3	3½	3½	4
225000	1¼	2½	2½	3	3	3½			
250000	1¼	2½	2½	3	3	3½			
300000	1¼	2½	3	3	3½	3½			
350000	1¼	2½	3	3½	3½	4			
400000	1¼	3	3	3½	4	4			
450000	1½	3	3	3½	4	4½			
500000	1½	3	3	3½	4	4½			
550000	1½	3	3½	4	4½	5			
600000	2	3	3½	4	4½	5			
650000	2	3½	3½	4					
700000	2	3½	3½	4½					
750000	2	3½	3½	4½					
800000	2	3½	4	4½					
850000	2	3½	4	4½					
900000	2	3½	4	4½					
950000	2	4	4	5					
1000000	2	4	4	5					
1100000	2½	4	4½	6					
1200000	2½	4½	4½	6					
1250000	2½	4½	4½	6					
1300000	2½	4½	5	6					
1400000	2½	4½	5	6					
1500000	2½	4½	5	6					
1600000	2½	5	5	6					
1700000	3	5	5	6					
1750000	3	5	5	6					
1800000	3	5	6	6					
1900000	3	5	6						
2000000	3	5	6						

Not more than 9 wires shall be permitted in one conduit except as noted in Table 3. Where single conductor, single braid, solid wires only are used, four No. 14 wires may be installed in a ½ inch conduit and up to seven No. 14 wires in a ¾ inch conduit. Three No. 12 wires may be installed in a ½ inch conduit, four No. 10 wires in a ¾ inch conduit and three No. 8 wires in a ¾ inch conduit. For conduit runs having not more than the equivalent of two quarter-bends from end to end and not exceeding 50 feet in length, three No. 6 wires or six No. 8 solid conductor wires may be installed in a 1-inch conduit.

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

For groups or combinations not included in the above tables, the conduit shall 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.

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. A 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 or dry partitions if in unbroken lengths where passing through; but, where the wall or partition is damp, or where the raceway passes through a floor, an iron pipe sleeve shall be placed over the raceway and shall extend clear of either side of the wall or partition, or from the ceiling below to a point at least 3 inches above the flooring. Where protection from mechanical injury is necessary, the iron pipe sleeve shall extend to a point at least 5 feet above the flooring.

i. Metal raceways shall be grounded as prescribed in Section 130.9 of this code.

j. When combination metal raceways are used both for communication 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 paragraphs (m), Order 1305.03, and of paragraphs (a) to (d) inclusive, Order 1360.03 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. Wires of light and power systems shall enter and leave combination raceways by means of conduit work. In all other respects, the provisions of this section 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.

d. Wires of armored cables shall be of rubber-covered type. The armored cable shall carry a distinctive marker throughout its entire length.

e. Approved outlet boxes or fittings shall be installed at all outlets and switch points as required by paragraphs (a) and (b) of Order 1307.03. 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. The entire cable system shall be secured in place by suitable fastenings which will not injure the armor.

f. 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 and not less than two inches from the nearest edge, if their depth will permit.

g. When the cable is employed in accessible attics or roof spaces, it shall be installed as follows:

1. When run within five feet of the floor or floor joists, through bored holes in rafters or studs, or when run through bored holes in floor joists, cable shall be protected by substantial running boards extending at least one inch on each side of the cable or cables, and be securely fastened in place.

2. When within five feet of floor or joist, 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.

3. When carried along the sides of rafters, studs or floor joists, neither guard strips, nor running boards shall be required.

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 in-

ner edge of any bend shall be not less than five times the diameter of the cable.

i. At all points where the armor terminates, additional protection shall be afforded the conductors by approved means so that the conductors will be adequately bushed.

j. Type ACL (having a lead sheath under the armor) shall be used in underground service runs and where other circuits are embedded 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 the weather or to continuous moisture or dampness.

k. For the use of armored cable in under-plaster extensions, see Order 1305.10 of this Section.

l. Where alternating current is to be employed, all conductors of a circuit shall be contained within one armor 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 130.9 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 overload 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 any 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 water-proof 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 mechanically 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 130.9 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 signalling, 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 130.9 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 30 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 300 volts between conductors nor 150 volts to ground.

b. Cable shall only be used for wiring in residence buildings, and in outbuildings on the same premises, or for the wiring of office or mercantile occupancies in residence neighborhoods, which individual occupancies do not require more than four branch circuits.

c. Cable shall not be installed in masonry, concrete or fill in buildings in course of construction, nor where exposed to the weather, nor in continuously damp or moist locations.

d. 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.

e. 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 between outlets with approved fastenings spaced at intervals not exceeding three feet.

3. Vertical runs shall be protected within five (5) feet of the floor by a rigid conduit or pipe, or a substantial wood or metal protecting strip, placed over the cable and securely fastened in place.

4. Horizontal runs within five (5) feet of the floor shall be protected as specified in paragraph (3) above, unless substantial protection is afforded by fixed furniture.

5. Where passing through floors or within 6 inches of floors, cable shall be protected by a length of rigid conduit or pipe, passing through the floor, and extending at least 6 inches above the floor, in addition to the protection specified in sub-paragraph (3) above.

f. When employed in concealed wiring, cable shall be installed as follows:

1. In building under construction, shall be secured between outlets by approved fastenings spaced at intervals of not exceeding 4½ feet.

2. In finished buildings where impracticable to support the cable as specified in the preceding paragraph, cable may be fished from outlet to outlet.

g. 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 paragraphs a and b of Order 1307.03 shall be installed at all outlets and switch points. Where grounding is required by Section 130.9 of this Code, the grounding conductor shall be connected to the boxes or fittings by approved means.

h. Bends in cable shall be so made and other handling shall be such that the protective coverings of the cable will not be injured, and no bend shall have a radius less than five times the diameter of the cable.

i. Shall not be buried in walls, floors, or ceilings of plaster, cement, or similar finish.

j. When non-metallic sheathed cable is installed in conduit or in surface or underfloor raceways, the provisions of Orders 1305.03, 1305.04 and 1305.06 of this Section shall apply as far as practicable.

k. 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 and not less than two inches from the nearest edge, if their depth will permit.

l. Cable in accessible attics or roof spaces, shall be installed as follows:

(1) When run within five feet of the floor or floor joists, through bored holes in rafters or studs, or when run through bored holes in floor joists, cable shall be protected by substantial running boards extending at least one inch on each side of the cable or cables and securely fastened in place.

(2) When within five feet of floor or joist, 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.

(3) When carried along the sides of rafters, studs or floor joists, neither guard strips nor running boards shall be required.

m. Cable in unfinished cellars or basements, if not run through bored holes in beams or floor joists, shall be run on the under side of running boards not less than ⅞ inch by 1¾ inches when run at angles with floor joists or timbers, or on sides or faces of floor joists or timbers when run parallel with them. Three-wire assemblies of cables larger than No. 8 run at angles with floor joists or timbers need not have the guard rails specified in sub-paragraph 2 of the preceding paragraph.

n. In other places where subject to mechanical injury, cable shall be substantially protected by one of the above methods.

o. When thermal insulation is used in the hollow spaces of walls, and ceilings in which non-metallic sheathed cable is installed, only approved non-corrosive non-combustible, non-conducting materials shall be used, and these shall be applied in a manner not liable to place a strain upon the cable or supports.

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.

Supplement e. Metallic tubing and fittings shall be of the following electrical trade sizes, as determined by the internal diameter of the tubing.

Nominal Electrical Trade Size	Approximate Actual Internal Diameter of Tubing
⅜ inch	0.493 inch
½ inch	0.622 inch
¾ inch	0.824 inch
1 inch	1.049 inch

The ⅜ inch size is recognized only when used in under-plaster extensions as provided in Order 1305.10 of this Section.

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.

Supplement h. Electrical metallic tubing shall not be used for interior wiring systems of more than 300 volts between conductors or of more than 150 volts to ground, nor for wires larger than No. 8 gauge or fused at over 30 amperes.

Supplement i. Electric metallic tubing shall be used only in exposed dry locations where during installation or afterwards it will not be subject to severe mechanical injury nor to corrosive vapors.

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.

l. Wires used with electrical metallic tubing shall be Type R unless the surrounding temperature of the wire as installed will exceed 120° F. (49° C.), when types A or SB wires shall be used.

m. 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. Wires of different systems shall not occupy the same tubing. When alternating current is to be employed all conductors of a circuit shall be within one tube, except as provided for in underplaster extension 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.

n. The number of wires (none larger than No. 8) contained in any run of electrical metallic tubing shall not exceed that given in the following tables, except when special permission for a larger number is obtained. Supplement

TABLE 1

Two-Wire and Three-Wire Systems
No. of Wires in One Metallic Tube

Size of Wire	1	2	3	4	5	6	7	8	9	
	Trade Size of Metallic Tubing. I. D.									
14	½	½	½	¾	¾	1	1	1	1	Inch
12	½	½	¾	¾	¾	1	1	1	1	Inch
10	½	¾	¾	1	1	1	-------	-------	-------	Inch
8	½	¾	1	1	1	-------	-------	-------	-------	Inch

Where single, solid conductor, single braid wires only are used, ½-inch tubing may contain four No. 14 or three No. 12 wires; ¾-inch tubing may contain seven No. 14 wires or four wires of No. 10 or three wires of No. 8 gauge.

TABLE 2

Three-Conductor Convertible System

Size of Wires	Trade Size (I. D.) of Metallic Tubing
Two No. 14 and one No. 10	¾ inch
Two No. 12 and one No. 8	¾ inch

For groups or combinations not included in Table 2, the authority enforcing this Code may be consulted.

For such groups or combinations, it is recommended that the sum of the cross-sectional area of the several conductors in the group or combination shall not exceed 40 per cent of the area of the tubing to be used.

o. Wires in vertical runs of electrical metallic tubing, exceeding 100 feet shall be supported as is specified for wires in rigid conduits in paragraphs of Order 1305.03 of this section.

p. Installation of metallic tubing shall be grounded as is specified for other wiring methods in Section 130.9 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 specially approved for use with them at all junction, outlet and switch points. In general, the appropriate provisions of Section 130.7 of this Code 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, and Ordinary and Medium-duty 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 section are observed.

b. Such extensions shall be run in rigid or flexible conduit, armored cable, metal moldings, or electrical metallic tubing, of approved standard types. Standard sizes of conduit, cable, molding or tubing shall be used except that for single wires only, conduits or tubing may be not smaller than 5/16-inch. Raceways especially approved for this use may also be employed.

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. They shall not be run outside of the floor or suite in which they originate.

d. The methods of installation for such extensions shall be as given in the appropriate sections of this article for the kind of raceway employed, except that raceways may be used for single conductors even when alternating current is employed.

Order 1305.11. Decorative Lighting Systems.

a. Temporary installations of approved systems of decorative lighting shall be used only when permission therefor has been granted by the inspection department and where the difference of potential between the wires of any circuit does not exceed 150 volts and where the number of outlets and lamps connected to them is in no case such as to place more than 15 amperes on a branch circuit fuse.

Order 1305.12. Auto Transformers for Derived Wiring Systems and Circuits.

Transformers in which a part of the turns are common to both primary and secondary alternating-current circuit, ordinarily known as auto-transformers, shall not be used to supply any interior wiring system, 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-transformer. This rule, however, does not prohibit the use of auto-transformers in autostarters used for controlling induction motors, nor does it prohibit the use of auto-transformers for supplying motor-starting current to individual motors, nor for the supply circuits wholly within a device which also contains the auto-transformer.

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 cut-outs, 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.)

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
R15	Rubber-covered for max. voltage	1500
R25	Rubber-covered for max. voltage	2500
R35	Rubber-covered for max. voltage	3500
R50	Rubber-covered for max. voltage	5000
R70	Rubber-covered for max. voltage	7000
RL	Rubber-covered, leaded.	
AC	Wires for use in armored cable.	
ACL	Leaded wires for use in armored cable.	
RD	A "twin wire," having two rubber insulated fibrous covered conductors laid parallel under an outer fibrous cover.	

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

Size of Conductor	Type	R	R-15	R-25	R-35	R-50	R-70
American or B. & S. Gauge	For Working Pressures Not Over	600 Volts	1500 Volts	2500 Volts	3500 Volts	5000 Volts	7000 Volts
14 to 8		3	6	8	10	12	16
7 to 2		4	7	9	10	12	16
1 to 0000 C. M.		5	8	10	10	12	16
225,000 to 500,000		6	9	10	11	12	16
525,000 to 1,000,000		7	10	10	12	12	16
Over 1,000,000		8	10	10	12	14	18

d. All single rubber-covered wires and cables shall have a covering of fibrous material applied directly to the surface of the insulating wall. For any single-conductor wire there shall be at least one braid for sizes from No. 14 to and including No. 8. For all single-conductor cables larger than No. 8 there shall be at least two braids or a tape and a braid. For twin wires and twisted-pair wires and for all multiple-conductor cables there shall be a fibrous covering on each individual wire and in addition a braid enclosing the bunched conductors. For certain special service conditions, one or more additional coverings of fibrous material or of lead may be required. Fibrous coverings may be either braid or tape, but tape shall not be used for the final outer covering.

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 bunched 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 two conductors identified in this manner. The coverings of the other conductors shall be finished to show solid colors other than white or natural gray.

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. The varnished cambric shall be applied in layers and filled as may be specified, and shall have coverings conforming to the requirements for rubber-covered wire as prescribed in Order 1306.02 of this Section.

b. The thickness of the varnished cambric and filler shall be not less than those given in the following table:

Table of Thicknesses of Varnished Cambric and Filler in 64th Inches.

Size of Conductor, Gauge	For Working Pressures Not Over					
	600 Volts	1500 Volts	2500 Volts	3500 Volts	5000 Volts	7000 Volts
14-10	3	5				
8	3	5	7	8	11	14
7-2	4	5	7	8	11	14
1-0000	5	6	7	8	11	14
225,000 to 500,000 C. M.	6	6	8	9	11	14
525,000 to 1,000,000 C. M.	7	7	8	9	11	14
Over 1,000,000 C. M.	8	8	9	9	11	14

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 1315.03.

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 1306.12 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 and CFC), 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 following table. The cords listed in the table, except Types AT and CT, are recognized in sizes of 18 A. W. G. gauge and larger, except that Types P–64 and PWP–64 are recognized in 18 gauge only; Types P–32 and PWP–32 are recognized in 18 and 16 gauge only, and Type E is recognized in 16 gauge and larger.

Use			Type Letter	Trade Name	Braid on each Conductor	Filler	Outer Cover	
							Kind	Number
In Dry Places	Attached to a Device	Not Subject to Hard Usage	AT** CT**	Tinsel Cord	Cotton	None	Cotton or Silk	1
	Pendant		AFC	Heat Resisting Cord		One Cotton or Silk Braid on each Conductor or over all Conductors		
			CFC					
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
			PO-32					
			PO					
	Pendant and Portable	Not Subject to Hard Usage	C	Lamp Cord	Cotton or Silk	None	None	----------
			PD	Twisted Portable	Cotton	None	Cotton or Silk	1
			P-64	Reinforced Cord	Cotton	Rubber Jacket	Cotton or Silk	1
			P-32					
		Where Subject to Hard Usage	P					
			CA	Armored Cord	Cotton	None	Standard Armor	1
			PA	Armored Reinf'c'd Cord	Cotton	Rubber Jacket	Cotton & Standard Armor	2
In Damp Places	Pendant	Where Not Subject to Hard Usage	PWP-64 PWP-32 PWP	Moisture Proof Reinforced Cord	Cotton	Rubber Jacket	Cotton Moisture-Proofed	1
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°
			PAWP	Moisture Proof Armored Reinforced Cord	Cotton	Rubber Jacket	Cotton Moisture-proofed Standard Armor	2°
			SJ	Jun'r Hard Service Cord	None	Special Rubber Jacket	None	
		Subject Ex. Hard Usage	St	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°
Portable Heaters			H	Heater Cord	One Cotton or Silk Braid on Each Conductor or Over all Conductors.			

* Type K is suitable for use on theatre stages.

** Types AT and CT are suitable for use 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 theatre stages, for elevator lighting and control and in garages wherever flexible cords except Type H are permitted by this Code.

° Rubber-filled or varnished-cambric tapes may be substituted for the inner braids.

Except for types PO–64, PO–32 and PO, individual conductors are twisted together.

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.

f. One conductor of flexible cords shall have a continuous identifying marker readily distinguishing it from the other conductors. This marker shall be a tracer in the braid of any color contrasting with that of the braid or, in case of cords having no 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 color or colors which may be readily distinguished from white or natural gray.

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 of the specific type.

b. The cable shall have a continuous distinctive marking so that the marker 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 following section 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
					5
18	40.3	1,624	3	----------	10
16	50.8	2,583	6	----------	20
14	64.1	4,107	15	18	25
12	80.8	6,530	20	25	30
10	101.9	10,380	*25	30	50
8	128.5	16,510	35	40	70
6	162.0	26,250	50	60	80
5	181.9	33,100	55	65	90
4	204.3	41,740	70	85	100
3	229.4	52,630	80	95	125
2	257.6	66,370	90	110	150
1	289.3	83,690	100	120	200
0	325.	105,500	125	150	225
00	364.8	135,100	150	180	275
000	409.6	167,800	175	210	300
		200,000	200	240	325
0000	460.	211,600	225	270	350
		250,000	250	300	400
		300,000	275	330	450
		350,000	300	360	500
		400,000	325	390	600
		500,000	400	480	680
		600,000	450	540	760
		700,000	500	600	840
		800,000	550	660	920
		900,000	600	720	1,000
		1,000,000	650	780	1,080
		1,100,000	690	830	1,150
		1,200,000	730	880	1,220
		1,300,000	770	920	1,290
		1,400,000	810	970	1,360
		1,500,000	850	1,020	1,430
		1,600,000	890	1,070	1,490
		1,700,000	930	1,120	1,550
		1,800,000	970	1,160	1,610
		1,900,000	1,010	1,210	1,670
		2,000,000	1,050	1,260	

1 Mil = 0.001 inch.

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 of size Nos. 18 and 16 shall be used only for flexible cords and for fixture wires.

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. 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 as in the following 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.

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 15 of the Table of paragraph d–3 of this section.

2. The values and "demands" set forth in this section are

based on average load conditions and may be used safely for all installations which have been adequately designed. However, if at any time after the equipment is put in service it shall be found that conductors are of insufficient capacity to carry the actual load without over-fusing, they shall be increased to comply with the requirements for overload protection applying thereto. In any event the size of feeders shall be sufficient to carry, without overheating, the loads imposed upon them.

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 K of Order 1308.08 of this code, and the sum of these shall determine the size in accordance with Order 1306.12 of this Section.

d. 1. The current load for lighting and appliances shall be determined in accordance with the following tables 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 of this Section.

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.

(1) 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; for all excess over 2000 square feet, 60.

(2) Buildings constructed and used for multi-family dwellings (other than hotels):

One watt per square foot, plus 1000 watts per apartment for appliances.

For area of 2000 square feet, or less—demand 100.

For that part of the area in excess of the first 2000 square feet, a demand of 70, provided the number of apartments does not exceed ten. If the number of apartments is between 11 and 40, the second factor (70) shall be 60. For 41 or more apartments, the second factor (70) shall be 50. The demand for each feeder shall be determined in the same manner, i. e., by the area and the number of apartments supplied.

(3) Apartment Hotels (having provision for individual electric cooking):

One watt per square foot, plus 1000 watts per apartment for appliances.

For area of 2000 square feet or less, demand 100.

For that part of the area in excess of 2000 square feet, a demand of 70, provided the number of apartments does not exceed 10. If the number of apartments is between 11 and 40, the second factor (70) shall be 60. For 41 or more apartments, the second factor (70) shall be 50.

(4) 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.

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.

For the excess above 50,000 square feet per feeder, a demand of 70.

(5) 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. 6 below. Demand 100.

(6) Show Windows: 200 watts per linear foot, meas-

ured horizontally along the base of the show window—demand 100.

(7) Office Buildings: 2 watts per square foot.

For areas 10,000 square feet or less per feeder—demand 100.

For all excess above 10,000 square feet per feeder—demand 70.

(8) Industrial Commercial (Loft) Buildings: One watt per square foot—demand 100.

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.

(9) Garages: ½ watt per square foot, exclusive of the machine shop or display rooms, if any—demand 100.

(10) 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.

For the excess area above 25,000 square feet per feeder—demand 60.

(11) Schools: 1½ watts per square foot. For areas of 10,000 square feet or less per feeder—demand 100.

For the excess area above 10,000 square feet per feeder—demand 50.

(12) Storage Warehouses: ¼ watt per square foot.

For areas of 50,000 square feet or less per feeder—demand 100.

For the excess area above 50,000 square feet per feeder—demand 50.

(13) 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.

(14) 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 applied also to special uses, such as floor and outline lighting, signs, etc.

(15) 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 Factor		Number Ranges	Demand Factor
1	100		14	42
2	100		15	40
3	95		16	39
4	90		17	38
5	85		18	37
6	80		19	36
7	75		20	35
8	65		21	34
9	55		22	33
10	52		23	32
11	48		24	31
12	46		25	30
13	42	Over	25	30

Note: 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.

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 x 1 watt—sq. ft. = 4,500 watts

Allowance for appliances = 1,000 watts

COMPUTED LOAD = 5,500 watts

DEMAND SELECTED FOR THIS OCCUPANCY, first 2,000 square feet—Demand 100. Excess above 2,000 square feet—Demand 60.

4,500 square feet area

−2,000 square feet at 1 watt — sq. ft. x 1 (Demand 100) = 2,000 watts

2,500 square feet at 1 watt—sq. ft. x 0.6 (Demand 60) = 1,500 watts

Allowance for appliances = 1,000

LOAD AFTER APPLYING DEMAND ---------- = 4,500 watts

For 110-volt, 2-wire system:
4,500 watts ÷ 110 volts = 40.9 amperes.

SIZE OF CONDUCTORS = 2 No. 6.
(From table No. 612 of allowable carrying capacities of wires.)

For 220-volt, 2-wire system:
4,500 watts ÷ 220 volts = 20.45 amperes.

SIZE OF CONDUCTORS = 2 No. 10.
(From table No. 1 Order 1306.12 of allowable carrying capacities of wires.)

For 110–220 volts, 3-wire system:
4,500 watts ÷ (2 x 110 volts) = 20.45 amperes.

SIZE OF CONDUCTORS = 3 No. 10.

For 110–220 volts, 4-wire, 3-phase system:
4,500 watts ÷ (3 x 110 volts) = 13.63 amperes.

SIZE OF CONDUCTORS = 4 No. 14.
(From table No. 1 Order 1306.12 of allowable carrying capacities of wires.)

Note: 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 x 1 watt—sq. ft. --- = 700 watts
Allowance for appliances 1,000 ---------- = 1,000

COMPUTED LOAD per Apt. ---------- = 1,700 watts

DEMAND 100.
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 2,000 sq. ft., none—2,000 x 1 ----- = 2,000
For area in excess of the first 2,000 sq. ft., 35,400 x 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, from table No. 1, Order 1306.12, is No. 4/0 for each wire.

MAINS

AREA IN SQ. FT. 700 x 44 = 30,800 sq. ft. at 1 watt per sq. ft. ---------- = 30,800 watts
Allowance for appliances 44 x 1,000 ---------- = 44,000 watts

COMPUTED LOAD ---------- = 74,800 watts

DEMAND SELECTED for this occupancy
For first 2,000 sq. ft., none—2,000 x 1 ----- = 2,000 watts
For area in excess of first 2,000 sq. ft. 72,800 x 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, from table 1, Order 1306.12, is 450,000 C. M. each.

Note: The above calculation does not take account of ranges or other appliances using more than 1,650 watts each.

e. One neutral conductor may be employed for three sets of 3-wire or two sets of four or five-wire interior feeders. Where single two-wire final circuits are run from a meter bank to the premises of individual tenants, the circuits may be balanced on each side of the system and a common neutral be employed for not more than eight circuits on 3-wire direct-current or single-phase, and 5-wire 2-phase alternating-current systems, and not more than six circuits on 4-wire, 3-phase systems. All wires of the A. C. systems shall be run in the same conduit. The size of the neutral and the demand applying thereto shall be determined as specified in the previous paragraphs. In addition, the following further demand may be applied:

Type of System	Current Load in Outside Conductors After Applying Demand	Further Demand for Neutral Conductors
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 1306.14. 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 sur-

rounding 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 shall have insulating covering at least 3/64-inch in thickness for all conductor sizes No. 8 and less, except where type S cord is used.

h. Flexible cords not smaller than No. 18 gauge, and flexible cord 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 gauge, or larger if required by column 1 of table 1 of Order 1306.12, may be approved for use with specific devices on the medium-duty appliance branch circuits described in Order 1316.02 and which are fused at not over 25 amperes.

i. No wire smaller than No. 18 shall be used for fixture work or flexible cords, except as approved for specific devices.

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 and Order 2114 Industrial Lighting Code.)

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 oxidation.

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. Boxes and fittings not over 100 cubic inches in size, shall be composed of pressed steel, not less than No. 14 U. S. Sheet Steel Gauge (0.078 inch) in thickness, or of cast metal, having a wall thickness of not less than $\frac{1}{8}$ 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 enclosing joints in wires or to facilitate the drawing in of wires or cables. They are not intended to enclose 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 non-combustible, non-absorptive insulating bushing.

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.

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 oxidation.

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.

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 ¾ inch in thickness, thoroughly filled and painted. They shall be lined throughout with a non-combustible material, such as ⅛ inch rigid asbestos board firmly secured in place. Linings of slate, marble or approved composition shall be at least ¼ 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 case 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 enclosed fuses) and the door, unless the door is lined with an approved insulating material or is of a thickness of metal not less than No. 12 U. S. sheet metal gauge (0.109 inch), when the air space shall be not less than ½ 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 enclosures by means of covers, barriers or partitions extending from the bases of the devices, contained in the cabinet, to the door, frame, or sides of the cabinet, provided, however, that where the enclosure contains only those 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. Par-

tially enclosed back wiring spaces shall be provided with covers to complete the enclosure.

i. Cabinets and cutout boxes intended for outdoor use shall be of approved weatherproof type.

Order 1307.03. Installation of Boxes, Cabinets, and Outlet and Terminal Fittings.

a. At each outlet, switch, or junction point of conduit, metal raceway, armored cable or non-metallic sheathed cable, and at each outlet and switch point of concealed knob-and-tube work, an approved box shall be installed. In completed installations, the box shall be provided with a cover, unless a fixture canopy is present.

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

c. An approved outlet or terminal fitting shall be used at ends of conduit, armored cable and metal raceway systems from which wires are run without splice to appliances or to knob-and-tube wiring. The fitting shall provide a bushed hole for each wire. It need not be accessible when in knob-and-tube work. Such fittings shall not be used at outlets for fixtures.

d. Approved metal supports shall be used in new work for boxes and fittings which are not secured to a stud, joist, or similar fixed structural unit. Blocks of wood at least ⅞ inch in thickness may be used for supports if the blocks are rigidly secured to such structural units. Lath, of wood, metal, or composition, shall not be considered a fixed structural unit.

e. Boxes used to enclose flush devices shall be of such type that the devices will be completely enclosed on back and sides, and that substantial support for the devices will be provided. Screws for supporting the box shall not be used for the 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.

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 non-combustible, non-absorptive, insulating bushing.

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 conduit 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 ¼ inch. On wooden 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. 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, raceway, armored cable, non-metallic 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 hardwood cabinet is used, as provided for in Order 1307.02 c, each opening shall be equipped with 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. Metal boxes, cabinets, and fittings shall be grounded

where used with conduit, armored cable or metal raceway, or elsewhere when and in the manner specified in Section 130.9 of this code. Boxes, cabinets and fittings used with grounded conduit, armored cable and metal raceways are considered to be grounded by the connection to the conduit, cable or raceway.

For special provisions in hazardous locations see Section 133.2.

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.

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.

Order 1308.01. Cutout Bases.

a. The requirements of this section shall not apply to attachment plugs, car-lighting cutouts or protective devices for signal systems. Cutout bases for link fuses shall be approved only in capacities above 300 amperes and their spacing shall be at least as great as those given in the following table, which applies only to plain, open fuse blocks mounted on slate, marble or composition bases. If the fuse tips overhang the edges of the fuse block terminals, the spacings shall be measured between the nearest edge of the tips.

Ampere Capacity	Minimum Separation of Nearest Metal Parts of Opposite Polarity	Minimum Break Distance
Not over 125 Volts		
301–1500	1½	1½
Not over 250 Volts		
301–1500	2¾	2

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

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

d. Except for sealable service and meter cutouts the fuse terminals of enclosed fuse cutout bases shall be of either the Edison plug, spring-clip, knife-blade or other approved standardized types to take corresponding standard enclosed fuses. They shall be secured to the base by two screws or the equivalent, so as to prevent them from turning, and shall be so made as to secure a thoroughly good contact with the fuse.

e. End stops shall be provided to insure the proper location of the cartridge fuse in the cutout base.

f. Cutout bases for enclosed 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 PLUG OR CARTRIDGE CUTOUTS

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

SEALABLE SERVICE AND METER CUTOUTS

Not over 250 volts	Not over 600 volts
0– 30 amperes	0– 30 amperes
31– 60 amperes	31– 60 amperes
61–100 amperes	61–100 amperes
101–200 amperes	101–200 amperes

Order 1308.02. Link Fuses.

a. Link fuses shall not be used when of capacities of 300 amperes or less. When used in capacities of from 301 to 1500 amperes, they shall be rated to correspond to the ratings of cutout bases as given in the table of paragraph a, Order 1308.01, of this code.

b. Contact surfaces or tips of link fuses shall be of copper or aluminum, having good electrical connections with the fusible part of the strip.

c. Link fuses shall be stamped with 80% of the maximum current which they can carry indefinitely, thus allowing about 25% overload before the fuse melts.

d. Link fuses may be used only when mounted on approved bases which, except on switchboards shall be placed in approved cutout boxes or cabinets. A space of at least 2 inches shall be provided between the open-link fuses and metal, or metal-lined walls or metal, metal-lined or glass-paneled doors of cabinets or cutout boxes.

Order 1308.03. Enclosed Fuses.

a. The requirements of paragraphs c to g inclusive, of this section, do not apply to fuses for attachment plugs, car-lighting cutouts, nor to protective devices for signal systems.

b. The casings of enclosed fuses shall be sufficiently tight so that lint and dust cannot collect around the fusible link and become ignited when the fuse is blown. For non-renewable fuses the fusible wire shall be attached to the terminals in such a way as to make it difficult for it to be replaced when melted.

c. Enclosed fuses shall be classified to correspond with the different classes of cutouts, and shall be so designed that it will be impossible to put any fuse of a given class into a cutout which is designed for a current or voltage lower than that of the class to which the fuse belongs.

d. All fuses shall be marked with the 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 enclosed 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. The label for cartridge fuses shall bear the following: the name or trade-mark of the manufacturer and the voltage for which the fuse is designed.

e. 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 an hexagonal shaped recess in the top of fuses having porcelain or moulded composition tops, and when labels are used with such plug fuses the labels shall also be hexagonal in shape and fill the recess; or on plugs having solid metal caps, by an hexagonal impression either raised or lowered on the caps.

f. The fuse terminals shall be sufficiently heavy to insure mechanical strength and rigidity. The styles of enclosed plug and cartridge fuse terminals, except for use in sealable service and meter cutouts, shall be as follows:

Not over 250 volts.

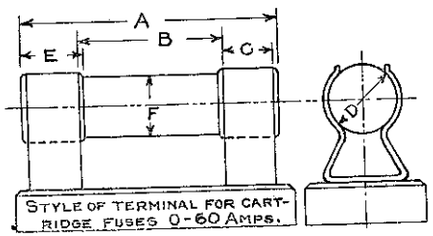
0– 30 Amps.	A. Cartridge fuse (ferrule contact). B. Approved plugs or cartridge fuses in approved casings for Edison plug cutouts not exceeding 125 volts, but including any feeder or circuit of a system having a grounded neutral, if no wire of the feeder or circuit exceeds 125 volts to ground.
31– 60 Amps.	Cartridge fuse (ferrule contact) for use also in approved casings for large size Edison plug type 250-volt cutouts.
61–100 Amps. 101–200 Amps. 201–400 Amps. 401–600 Amps.	Cartridge fuse (knife-blade contact).

Not over 600 volts.

0– 30 Amps. 31– 60 Amps.	Cartridge fuse (ferrule contact).
61–100 Amps. 101–200 Amps. 201–400 Amps. 401–600 Amps.	Cartridge fuse (knife-blade contact).

g. Cartridge enclosed fuses and corresponding cut-out bases, except for sealable service and meter cutouts shall conform to the dimensions given in the table following.

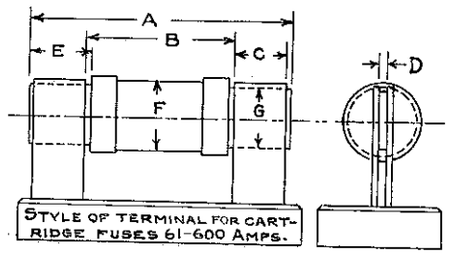
TABLE OF DIMENSIONS OF THE STANDARD CARTRIDGE



Form 1. CARTRIDGE FUSE—Ferrule Contact

Voltage	Rated Capacity Amperes		A Length over Terminals Inches	B Distance Between Contact Clips Inches	C Width of Contact Clips Inches
Not over 250	0–30 31–60	Form 1	2 3	1 1¾	½ ⅝
	61–100 101–200 201–400 401–600	Form 2	5⅞ 7⅛ 8⅝ 10⅜	4 4½ 5 6	⅞ 1¼ 1¾ 2⅛
Not over 600	0–30 31–60	Form 1	5 5½	4 4¼	½ ⅝
	61–100 101–200 201–400 401–600	Form 2	7⅛ 9⅜ 11⅝ 13⅜	6 7 8 9	⅞ 1¼ 1¾ 2⅛

NATIONAL ELECTRICAL CODE
ENCLOSED FUSES



Form 2. CARTRIDGE FUSE—Knife Blade Contact

D Diameter of Ferrules or Thickness of Terminal Blades Inches	E Min. Length of Ferrules or of Terminal Blades outside of Tube Inches	F Diameter of Tube Inches	G Width of Terminal Blades Inches		Rated Capacity Amperes
9/16 9/16	½ ⅝	½ ¾	---------- ----------	Form 1	0–30 31–60
⅛ ⅜ 13/16 ¼ ¼	1 1⅜ 1⅞ 2¼	1 1½ 2 2½	¾ 1⅛ 1⅝ 2	Form 2	61–100 101–200 201–400 401–600
13/16 1 1/16	½ ⅝	¾ 1	---------- ----------	Form 1	0–30 31–60
⅛ ⅜ 13/16 ¼ ¼	1 1⅜ 1⅞ 2¼	1¼ 1¾ 2½ 3	¾ 1⅛ 1⅝ 2	Form 2	61–100 101–200 201–400 401–600

Order 1308.04. Circuit-breakers and Thermal Cutouts.

a. Circuit-breakers shall be substantial in construction, and shall have ample metal for stiffness. The contact parts shall be arranged so that thoroughly good bearings are obtained. All circuit-breakers shall be provided with easily accessible means of manual tripping and resetting without injury to the operator.

b. Thermal cutouts shall be approved types and shall be mounted in approved metal enclosures.

c. An air circuit-breaker of 0–15 ampere capacity, used for branch lighting and appliance 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.

Order 1308.05. General: Use of Automatic Overload Protective Devices.

a. In general, automatic overload protective devices shall be provided in all constant-potential interior wiring systems, and shall be of such character and so placed as to protect each ungrounded conductor.

b. Nothing in this section shall be considered as prohibiting the use of two single-pole circuit-breakers for the protection of ungrounded 2-wire circuits.

c. In general a conductor shall be considered as properly protected by the automatic overload protective device employed in series with it when the automatic overload protective device is so selected and adjusted as to open and interrupt the circuit at a predetermined overload.

(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 time-limit automatic overload protective devices are used, they shall be so selected and adjusted as to operate at not greater than 110% of the allowable carrying capacities of wires as established in Table 1, Order 1306.12, Section 130.6 of this Code.

(3) When instantaneous circuit-breakers are used, they shall be so selected and adjusted as to operate at not greater than 160% 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 subsequent orders of this Section of this Code, the above general requirements shall be modified. These cases are covered under special headings, such as Motors and Motor Circuits.

d. Each ungrounded conductor of a circuit shall be protected by an automatic overload protective device inserted in series with said conductor, except when the automatic overload protective device next back in line of the supplying circuit sufficiently protects the supplied conductor or as provided in paragraph p of this order. The automatic overload protective device shall be located at the point where the conductor received its supply except where specifically permitted by other Orders of this Section to be located elsewhere. (See 1308.08 a, exception 3 to table)

Exception: In large industrial buildings, where mains are run at considerable elevations and in which the fuses or circuit-breakers therefore may not be readily accessible, as required by 1312.02–b below, when placed in accordance with this order, the fuses or circuit-breakers may be omitted at the point where such change in size is made, provided the following conditions are met:

(1) The current-carrying capacity of the smaller conductors shall be at least one-third that of the mains.

(2) The smaller conductors, between the point where they tap the mains and the fuses or circuit-breakers for their protection, shall be enclosed in rigid metal conduit, the length between these two points shall be as short as practicable, but in no case greater than 50 feet, and there shall be no taps or branches between these points.

e. No automatic overload protective device shall be placed in any permanently grounded wire, except a circuit-breaker which simultaneously opens all conductors of the circuits and except as provided in Orders 1308.07 and 1308.08 of this Section.

f. At the locations in interior wiring systems where the size or capacity of conductors is changed and automatic overload protective devices are inserted to properly protect the smaller conductors, it is understood that if the circuit contains a grounded conductor the size of the grounded conductor may be changed in proportion to the reduction in size of ungrounded conductors although no protective device is provided for such ~~un~~grounded conductor.

Note: It is recommended that the automatic overload protective device employed at any one point of an interior wiring system shall embody the same identical type of protection for each ungrounded conductor of the circuit.

g. Except when placed on switchboards or the equivalent which are located in approved rooms or fireproof electric closets, all cutout bases, circuit-breakers and fused switches shall be enclosed in approved cabinets or cutout boxes or shall be so designed or otherwise protected or located so that live parts will not be exposed to accidental contact. They shall, in all cases, be placed in readily accessible locations.

h. Cutout bases, fused switches and circuit-breakers when installed in locations exposed to moisture shall be mounted in approved weatherproof cutout boxes or cabinets. External parts when within 8 feet of the floor, platform or ground shall be of non-combustible, non-absorptive insulating materials or if of metal shall be grounded.

i. Cutout bases and circuit-breakers shall not be placed where exposed to mechanical injury nor in the vicinity of easily ignitible material. If the occupancy of the building is such that a suitable location free from exposure to mechanical injury or remote from easily ignitible material cannot be found an approved metallic enclosure shall be provided.

For equipments in hazardous locations, see Section 133.2.

j. Cabinets shall in all cases be placed in a vertical position except by special permission and under conditions whereby automatic overload protective devices installed in such cabinets are thoroughly safeguarded from attendant hazards.

k. Except as provided in Orders 1308.05, 1308.07 and 1308.08 of this section 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 the circuit-breakers of the time-limit and of the instantaneous types, shall not be set more than 10 percent and 60 percent respectively above the allowable carrying capacity of the wire unless a fuse of a rating which properly protects the wires is also installed on the circuit.

l. For the protection of wires having safe carrying capacities exceeding the rated capacity of the largest approved enclosed-type fuse, approved enclosed 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 bus bars 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.

m. Fixture wires or flexible cords of No. 16 or No. 18 gauge shall be considered as protected by 15-ampere fuses. Flexible cords of No. 18 gauge or larger, approved for use with specific devices which may be used on the medium-duty appliance branch circuits described in Order 1316.02, shall be considered as protected by the 25-ampere fuses of such circuits.

n. Fused rosettes shall not be used.

(See order 1314.06d).

o. An automatic circuit-breaker, except as provided for generators in Order 1310.02 of this code, when installed without other automatic overload protective devices, shall have one pole in each ungrounded conductor.

p. The number of over-current units for circuit protection shall not be less than shown in the following table.

(For table of over-current units for motor protection, see Order 1308.08a–6.)

SYSTEM	*Number and location of Over-current, Units, such as Fuses, 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., Midpoint 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 or 5-Wire, 2-Phase, Neutral 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.)

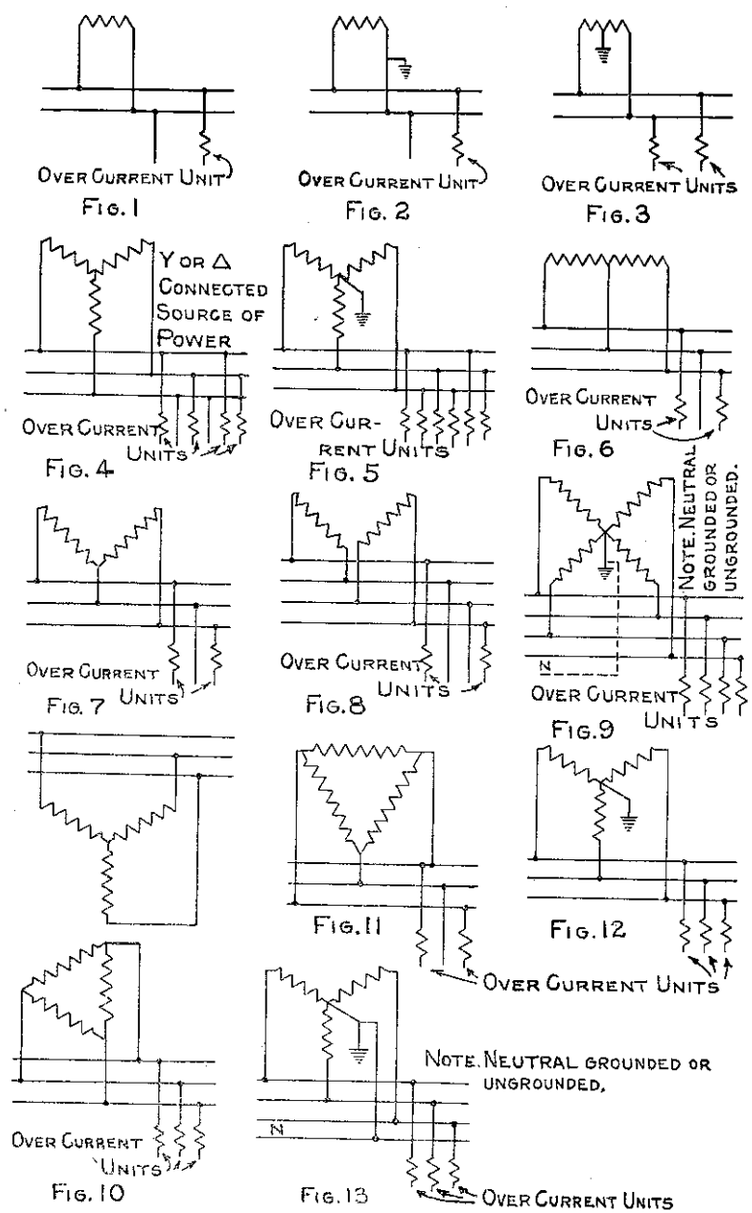
* 1. Where the above calls for one overload unit, this may consist of one fuse, one series over-current tripping device, or the combination of one current transformer and one secondary over-current tripping device.

2. Where it calls for two overload units, these may consist of two fuses, 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 fuses, three series over-current tripping devices, the combination of two or three secondary over-current tripping devices with three current transformers, or two series or secondary over-current tripping devices and one fuse.

4. Where it calls for four over-current units, these may consist of four fuses, four series over-current tripping devices, four current transformers with four secondary over-current tripping devices, or two series or secondary over-current tripping devices with two fuses.

The combinations of fuses with series or secondary over-current tripping devices mentioned under (3) and (4) above are to be discouraged for obvious reasons.



q. 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.

r. *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.

s. *Inclosure.* Current-carrying parts of switches, fuses, or automatic circuit breakers of more than 300 volts to ground shall be provided with enclosure guards, effective during ordinary operation; and if accessible to other than qualified persons, current-carrying parts of more than 150 volts to ground shall be provided with such enclosing guards.

t. *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 1308.06. Services.

For equipment at services including automatic overload protective devices, see order 1304.05 of Section 130.4, and Order 1350.09 of Section 135.0 of this Code.

Order 1308.07. Lighting and Appliance Branch Circuits.

a. For the purpose of this Section the terms "Outlets" and "Appliances" shall be defined as follows:

"Outlet"—An outlet is that fixed point on a branch circuit at which current is taken to supply lighting fixtures or appliances. An outlet having a fixture with more than one socket attached shall be considered as one outlet. An outlet having a multiple receptacle installed therein shall be considered as one outlet.

"Appliances"—Appliances are current consuming devices for domestic or general commercial use, such as heating, cooking and small motor operated devices, etc., suitable for use on the branch circuits described in Order 1316.02 of Section 131.6.

For definitions of "Branch Circuit", "Lighting Branch Circuits", "Appliance Branch Circuits" and "Combination Lighting and Appliance Branch Circuits" see the Introductory Part of this Code.

b. 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 so protected in the ungrounded wires only. In locations where the conditions of grounding or the liability of the reversal of connections warrant, the inspection 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, even though the grounded conductor is identified and properly connected.

c. Two-wire branch circuits on ungrounded systems shall be protected by a fuse in each wire.

d. Circuit-breakers, if used in lieu of fuses, shall be of a type specifically approved for this purpose.

e. Three-wire branch circuits may be run from direct-current or single-phase alternating-current systems having a grounded neutral, in which case the neutrals of the branch circuits shall not be inter-connected except at the center of distribution.

f. Branch circuits in general, and except as described elsewhere in this code, shall be protected by fuses of no greater rated capacity than

15 amperes ---------- at 125 volts or less
10 amperes ---------- at 126 to 250 volts

g. In general, on a two-wire branch circuit and on either side of a three-wire branch circuit the number of outlets shall not exceed 12.

For lighting branch circuits and combination lighting and appliance branch circuits which do not supply floor areas greater than 1200 square feet per circuit, the above outlet restriction may be waived, provided such circuits do not have connected loads greater than 10 amperes for combination lighting and appliance branch circuits.

It is understood that by connected load is meant fixed load, exclusive of loads which may be connected to appliance outlets.

greater than 15 amperes for lighting branch circuits nor

h. Branch circuits supplying only sockets or receptacles of the mogul type shall have the wire protected by fuses having a rated capacity not greater than

40 amperes ---------- at 125 volts or less
20 amperes ---------- at 126 to 250 volts

i. If protected by 40 or 20 ampere fuses as above, wire not smaller than No. 12 shall be used for wiring fixtures with mogul sockets and receptacles and may also be used for taps not over 18 inches long from the circuit wires to the points of suspension of the fixtures.

j. The number of mogul sockets on a 2-wire branch circuit and on either side of a 3-wire branch circuit shall not exceed eight (8) except by permission of the authority enforcing this code.

Order 1308.08. Motors and Motor Circuits.

a. Motors used for continuous duty. Except as otherwise provided in this section, the following tables shall govern the minimum allowable size of the conductors of any individual motor circuit from the main or feeder to the motor, and the maximum allowable rating or setting of the circuit and motor automatic overload protective devices to be used in each ungrounded conductor of any individual motor circuit. These tables are based upon a conductor current-carrying capacity and rating or setting of motor-running protective device, of 125% of the motor full-load current rating, with branch-circuit fuse protection according to the following percentages of the motor full-load current.

Type of Motor	Per Cent Motor Full-Load Current
Single-phase, repulsion or split-phase starting	300
Squirrel-cage, full-voltage starting	300
Squirrel-cage, reduced voltage starting (not more than 30 amperes)	250
High-reactance squirrel-cage (not more than 30 amperes)	250
Squirrel-cage, reduced-voltage starting (more than 30 amperes)	200
High-reactance squirrel-cage (more than 30 amperes)	200
Slip-ring A. C. and D. C.	150

(1) For motors having larger full-load current ratings than those given in these tables, calculations for the sizes of conductors and rating or setting of protective devices shall be made on the same basis as the foregoing.

(2) The maximum setting of circuit-breakers for such use shall not be in excess of that specified in sub-paragraph 5 of this section.

(3) Although it is desirable to keep the branch-circuit protection at as low a rating as is possible, cutout bases for such branch-circuit fuses shall not be of a smaller size than that required to accommodate the branch fuses specified in the following tables for any value of motor full-load current.

(4) 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. 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 cutout will accommodate fuses rated not less than is specified in the table for motor branch-circuit fuses.

(5) Where thermal cutouts or thermal relays are used for time-limit automatic overload protection and the values given in Column 6 of Table 1 following do not correspond to standard sizes or ratings, the next higher standard rating or size of thermal cutout or relay may be used. For long runs it may be necessary, in order to avoid excessive voltage drops, to use conductors of sizes larger than the minimum sizes given in the following tables.

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 following the first paragraph of this section.)			
	Rubber	Varnished Cambric	Slow-Burning	Max. Rating of N. E. C. fuses	Max. Setting of time-limit protective device	Squirrel-Cage, full-voltage starting Single-phase repulsion or split-phase	Squirrel-cage, reduced-voltage starting High-reactance squirrel-cage*** (up to 30 a.)	Squirrel-cage, reduced voltage starting High-reactance squirrel-cage*** (above 30 a.)	Slip-Ring A. C. and D. C.
Amperes				Amperes	Amperes	Amperes	Amperes	Amperes	Amperes
Col. No. 1	2	3	4	5	6	7	8	9	10
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	80	----------	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 following the first paragraph of this section.)			
	Rubber	Varnished Cambric	Slow-Burning	Max. Rating of N. E. C. fuses	Max. Setting of time-limit protective device	Squirrel-Cage, full-voltage starting Single-phase repulsion or split-phase	Squirrel-cage, reduced-voltage starting High-reactance squirrel-cage*** (up to 30 a.)	Squirrel-cage, reduced voltage starting High-reactance squirrel-cage*** (above 30 a.)	Slip-Ring A. C. and D. C
Amperes				Amperes	Amperes	Amperes	Amperes	Amperes	Amperes
Col. No. 1	2	3	4	5	6	7	8	9	10
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.	----------	----------	----------	----------

FULL-LOAD MOTOR CURRENTS‡

TABLE 2
Two-Phase A. C. Motors (4-wire)†

	Squirrel-Cage Induction-Type Amperes					Wound-Rotor and High-Reactance Squirrel-Cage Type Amperes				
H. P.	110V.	220V.	440 V.	550 V.	2200 V.	110 V.	220 V.	440 V.	550 V.	2200 V.
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		6.8	3.4	1.7	1.3	
1½*	7.7	4.0	2	1.6						
2*	10.4	5	3	2.0		12.5	6.2	3.1	2.5	
3		8	4	3.0		17.3	8.7	4.3	3.4	
5		13	7	6			13	6.5	5.2	
7½		19	9	7			22	11	9	
10		24	12	10			24	12	10	
15		33	16	13			39	20	16	
20		45	23	19			49	25	20	
25		55	28	22	6		58	29	23	7
30		67	34	27	7		71	36	29	8
40		88	44	35	9		92	46	37	10
50		108	54	43	11		110	55	44	12
60		129	65	52	13		130	65	52	14
75		156	78	62	16		163	82	66	17
100		212	106	85	22		213	106	85	22
125		268	134	108	27		269	135	108	27
150		311	155	124	31		315	157	125	32
200		415	208	166	43		430	215	173	45

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

† Values of current in common wire of 2-phase 3-wire system will be 1.41 times values given.

‡ These values of full-load currents are average for all speeds and frequencies.

* For the running protection of motors of 2 H. P. and less see sub-paragraph 1 below.

** For the grouping of small motors under the protection of a single set of fuses see sub-paragraph 2 below.

*** High reactance squirrel-cage motors are those designed to limit the starting current by means of deep slot-secondaries or double-wound secondaries.

TABLE 4
Three-Phase A. C. Motors

	Squirrel-Cage Induction Type Amperes					Wound-Rotor and High-Reactance Squirrel-Cage Type Amperes				
H. P.	110 V	220 V	440 V	550 V	2200 V	110 V	220 V	440 V	550 V	2200 V
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		7.8	3.9	2	1.6	
1½*	9.4	4.7	2.4	2.0						
2*	12	6	3	2.4		14.4	7.2	3.6	2.9	
3		9	4.5	4		20.0	10	5	4	
5		15	7.5	6			15	7.5	6	
7½		22	11	9			25	13	10	
10		27	14	11			28	14	11	
15		38	19	15			45	23	18	
20		52	26	21			56	28	22	
25		64	32	26	7		67	34	27	7.5
30		77	39	31	8		82	41	33	9
40		101	51	40	10		106	53	42	11
50		125	63	50	13		128	64	51	14
60		149	75	60	15		150	75	60	16
75		180	90	72	19		188	94	75	19
100		246	123	98	25		246	123	99	25
125		310	155	124	32		310	155	124	31
150		360	180	144	36		364	182	145	37
200		480	240	195	49		490	245	196	52

TABLE 5
Direct-Current Motors
Amperes

H. P.	115 V.	230 V.	550 V.
½*	4.5	2.3	
¾*	6.5	3.3	1.4
1*	8.4	4.2	1.7
1½*	12.5	6.3	2.6
2*	16.1	8.3	3.4
3	23.0	12.3	5.0
5	40	19.8	8.2
7½	58	28.7	12.0
10	75	38	16.0
15	112	56	23.0
20	140	74	30
25	185	92	38
30	220	110	45
40	294	146	61
50	364	180	75
60	436	215	90
75	540	268	111
100		357	146
125		443	184
150			220
200			295

The following exceptions to the foregoing tables shall be recognized:

(1) Motors of 2 H. P. or less shall be considered as being sufficiently protected by the automatic overload protective devices used to protect the conductors of the motor circuits as specified in the foregoing tables.

It is recommended that the running protection specified in the 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 fuses and with or without other current-consuming devices in the circuit shall be considered as being sufficiently protected if the rating of the fuses does not exceed 15 amperes and the total wattage of the circuit does not exceed 1320 or by the 25 ampere fuses of the medium-duty appliance branch circuits, described in Order 1316.02 of Section 131.6. No individual motor of such a group shall have a full-load rated current of more than 6 amperes.

(3) Automatic overload protective devices may be omitted at the point where the conductors carrying the current of only one motor are connected to the mains, provided either that, (a) conductors having a carrying capacity equal to that of the mains are carried to the motor running protective devices, or that (b) the carrying capacity of these conductors is at least ⅓ of that of the mains to which they are connected, the length of such conductors to the motor running protective devices is not greater than 25 feet and they are suitably protected from mechanical injury. In such cases consideration should be given to the interrupting capacity of the motor running protective device. When thermal cutouts are used this will require the installation of approved fuses for the protection of these mains, the fuses to have a rating not exceeding that indicated on the smallest thermal cutout in the group protected.

(4) For the protection of motors used on cranes and hoists see Order 1330.06 of this code.

(5) Except for the protection of thermal cutouts, automatic overload circuit-breakers of the time-limit type may be used for A. C. or D. C. motor branch-circuit protection and automatic overload circuit-breakers of the instantaneous type may be used for D. C. motor branch-circuit protection under the conditions specified in paragraph d, provided the settings are not greater than those given in the following table:

Type of Motor	Circuit-Breaker Setting Per Cent. of Motor Full-Load Current.	
	Instantaneous Type	Time-Limit Type
Single-phase, repulsion or split-phase starting		250
Squirrel-cage, full-voltage starting		250
Squirrel-cage, reduced-voltage starting (not more than 30 amperes)		200
Squirrel-cage, reduced-voltage starting (more than 30 amperes)		200
High-reactance squirrel-cage (more than 30 amperes)		200
Slip-Ring		150
Direct-Current (not more than 50 H. P.)	250	150
Direct-Current (more than 50 H. P.)	175	150

(6) When protective devices other than fuses are used for the running protection of motors, the following table shall govern the minimum allowable number and the location of the overload units, such as trip coils, relays, or thermal cutouts.

Kind of Motor	Supply System	Number and location of overload 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.

b. Motors used for short time duty. When motors are used in classes of service having short time duty (A. I. E. E. Standard) conductors having carrying capacities differing from those given in the tables in paragraph (a) will be required in motor circuit. In the majority of cases the carrying capacity need not exceed the percentages of the motor name-plate 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	Percentage of Name-Plate Current Rating				
	5-Minute Rating	10 & 15 Minute Rating	30 & 60 Minute Rating	2-Hour Rating	Continuous Rating
Operating valves raising or lowering rolls	110	120	150	200	250
Rolling tables	110	120	135	180	200
Hoists, rolls, ore and coal-handling machines	110	115	120	150	170
Freight and passenger elevators, shop cranes, tool heads, pumps, etc	110	110	110	120	140

c. 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% of the full-load secondary current of the motor, and between the con-

troller 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

d. Fuses shall not be required in series with automatic overload protective devices (except thermal cutouts) of other types (a) on main switchboards, (b) where otherwise subject to competent supervision, (c) where next back on the line there are fuses rated or a time-limit circuit-breaker set at not more than 500%, or an instantaneous-type circuit breaker set at not more than 700% of the motor name-plate current rating.

e. Automatic overload protective devices other than fuses, used for either motor or motor-circuit protection, shall have a continuous current-carrying capacity of at least 115% of the full-load current rating of the motor.

f. A controller for a D. C. Motor, which has an overload release device operative during the starting as well as the running period, may also serve as the running overload protective device.

g. The controller for an A. C. motor may also serve as the running overload protective device if it is equipped with the number of overload units (trip coils, relays or thermal cutouts) called for in the table of sub-paragraph a–6 of this section, and if it is operative when in the running position to open all of the ungrounded conductors automatically under overload.

h. Motor running protective devices may be shunted or cut out during the period for starting the motor, and the motor and its 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 500%, or an instantaneous-type circuit-breaker set at not more than 700% of the motor name-plate current rating.

i. When a switch is used to shunt the motor running protective device during the starting period, it shall be of a type that cannot be left in the starting position.

j. The control circuits of a magnetic controller shall be considered as being sufficiently protected by the motor-circuit protective device, provided they are suitably protected from mechanical injury and do not extend beyond the machine on which the controller may be installed.

k. In many cases conductors of a feeder or main circuit supplying a group of motors need not have a carrying capacity equal to the sum of the full-load current ratings of the motors supplied. A diversity factor may be permitted by the authority enforcing these regulations to be used in determining the carrying capacity of these feeders or main circuits, the value of this factor depending on the size and number of the motors supplied and the character of the load.

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 Section 131.6 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 fuse.

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 fuse.

Order 1308.13. Protection of Switchboard Instruments.

a. Enclosed fuses shall be used to protect instruments and pilot lights on switchboards. Approved enclosed 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 overload 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.

SECTION 130.9. GROUNDING

This Section treats primarily of protection in the use of electrical circuits and equipment by grounding, but where in this code protection by insulation or isolation is deemed effective these methods are recognized as alternatives.

The Introductory part of this code contains the orders covering the proper methods of grounding, the type and size of ground conductors required and the ground electrodes to be used. This section contains orders on where and when utilization equipment must be grounded.

Order 1309.01. General.

a. *In Introductory Part.*

b. The grounding connection, including electrode and grounding conductor, shall be permanent and effective and shall always be made on a continuous-metallic underground water piping system if one is available. In the absence of such a water piping system, a system ground conductor or a secondary neutral grid shall be used if available.

c. Where such a water piping system, a system ground conductor, or a secondary neutral grid is not available, the grounding connection shall be made in a manner to secure the most effective ground and by any of the following methods:

(1) The metal frame of the building, when effectively grounded;

(2) A continuous metallic underground gas piping system;

(3) A local metallic underground piping system, metal well casing and the like; or (See Order 1031 F)

(4) An artificial ground whose electrode consists of a driven pipe, driven rod, buried plate, or other device approved for the purpose.

d. *In Introductory Part.*

e. The combined resistances of the grounding conductor and its connection with the ground shall not exceed 3 ohms for water-pipe connection nor 25 ohms for buried or driven grounds. Where it is impracticable to obtain with one ground artificial ground resistance, as low as 25 ohms, this requirement shall be waived, and two artificial grounds, at least six feet apart and with combined area of not less than four square feet, shall be provided.

It is recommended that ground connections when installed be tested for resistance particularly when multiple grounding to water pipe is not used.

f. Where a system ground conductor or secondary neutral grid is employed it shall be effectively grounded at intervals which will satisfy the requirements as to current-carrying capacity and resistance prescribed in this Section.

Order 1309.02. Grounding Distribution or Supply Systems.

The provisions of this Order apply only to distribution or supply systems which are electrically connected to interior wiring systems and with respect to the protective grounding of such interior wiring systems.

a. Two-wire direct current systems supplying interior wiring systems and operating at not to exceed 300 volts between wires shall be grounded on one conductor and at the supply station, but not at individual services.

It is recommended that two-wire direct-current systems be grounded in the same manner if a neutral point can be established and if 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 two-wire direct-current systems be not grounded if the voltage to ground of either conductor would exceed 300 volts after grounding.

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

c. Secondary-alternating-current distribution systems supplying interior wiring systems shall be grounded if they can be so grounded that the maximum voltage to ground does not exceed 150. Similar systems operating with the voltage to ground exceeding 150 volts may be grounded. The ground connection for a grounded secondary alternating-current distribution system shall be made, except as provided below, on every individual service. Additional ground connections may be made on the leads of the transformer or transformers or at one or more points on the

system. By permission of the authority enforcing this code (1) any individual ground connection may be omitted provided there are other good ground connections or (2) transformer or system grounding solely may be used.

It is recommended that such systems be grounded as provided herein, if the voltage to ground exceeds 150 volts, but does not exceed 300 volts.

d. 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 ground protection after the fuses have opened.

Order 1309.03. Grounding Interior Wiring Systems.

a. Direct-current interior wiring systems shall not be grounded either at individual services or elsewhere on the interior system.

b. Alternating-current interior wiring systems containing a conductor corresponding to a grounded conductor of the distribution system shall be grounded. Every lighting and/or appliance branch circuit shall have one wire continuously identified, grounded and connected to each lamp or appliance on the circuit, except that two-wire branches tapped from the outside wires of a 3-wire single phase circuit within the same premises will be permitted if no fuse is omitted and no single pole switches or sockets are used.

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 the others: the identified common conductor;

(4) Multiphase systems having one phase grounded: identified conductor.

(5) Multiphase systems in which one phase is used as in (2): the identified neutral conductor.

d. The grounding connection for an interior wiring system or for any circuit electrically connected to the service conductors shall be made on the supply side of the service switch before the wiring is put in use. For an interior system not electrically connected to exterior conductors, the grounding connection shall be made at the transformers, generator, or other source of supply, or at a switchboard, and on the supply side of the first switch controlling the system. If one of the conductors is identified, the grounding connection shall be made to the identified conductor, commonly known as "the white wire."

e. The grounded conductor of an interior wiring system shall be connected from one point only within the building to the grounding electrode or electrodes.

f. Electric furnace circuits need not be grounded.

Order 1309.04. Grounding Interior Conduit and Other Interior Wiring System Raceways of Metal.

a. All metallic conduit, armored cables, metal raceway, metallic underfloor duct, electrical metallic tubing systems and other metallic raceways shall be grounded, whether the contained interior wiring system is grounded or ungrounded, unless in runs of less than 25 feet and free from metallic contact with the ground and from adjacent grounded metal and are guarded when within reach from grounded surfaces. Service conduit need not be grounded under the conditions given in paragraph ~~f~~ of Order 1304.04 of Section 130.4 of this Code.

b. The grounding connection for such systems shall be made at a point as near as practicable to the source of supply, but the point of attachment shall be such that no run of conduit, cable and the like is grounded through a run of smaller size unless the provisions of "paragraph (b) 6, Order 1032 of this Code are satisfied.

c. Where the service conduit or service-cable sheath is grounded in accordance with the foregoing, its grounding conductor shall be run from it directly to the ground, no portion of the service-switch box, or house conduit, being interposed in the grounding circuit. The following exceptions are permitted: Where the service-switch box or house conduit is grounded, and is installed in dry, non-corrosive locations, the service-switch box may be interposed in the grounding circuit of the service conduit provided that bonding jumpers or ground clamps or lugs or devices approved for the purpose are used.

For special requirements in Hazardous Locations, see Orders 1332.04 and 1332.05 of Section 133.2 of this Code.

d. Interior conduit and other interior wiring systems raceways of metal, exposed metal of fixed current using equipment and control apparatus that are required to be grounded, the service conduit, service-cable sheath and service equipment may use the interior wiring system grounding conductor and its electrode for grounding when the connection is made on the supply side of the service switch and

Supplement

provided that the supply system is grounded at two or more locations not in the same building to a continuous metallic underground piping system, otherwise where grounded they shall each have a separate grounding conductor and where artificial grounds are used they shall have separate electrodes.

e. Where sections of conduit, armored cable, metal raceways and the like are required to be grounded, they shall be bonded together and grounded or each section or piece shall be grounded separately.

f. The point of attachment of the grounding conductors provided in accordance with this Section shall be accessible if practicable.

Order 1309.05. Grounding Fixed Equipment.

a. Exposed non-current carrying metal parts of fixed equipment such as the following, shall be grounded as provided in this and other orders of this code.

(1) Service equipment, as provided in 1304.05–i.

(2) Generators operating in excess of 150 volts where accessible to other than qualified persons as provided in 1310.02–f.

(3) Fixed motors operating at a potential in excess of 150 volts where accessible to other than qualified persons as provided in 1310.03–l.

(4) Auto-transformer starters as provided in 1310.05–e.

(5) Switch and circuit-breaker enclosures with any wire over 150 volts to ground where accessible to other than qualified persons as provided in 1312.02–d.

(6) Switchboard instrument cases as provided in 1313.02–g.

(7) Lighting fixtures as provided in 1314.03–a and b.

(8) Arc lamps on circuits in excess of 150 volts to ground as provided in 1315.02–b.

(9) Mercury-vapor lamps where within easy reach from grounded surfaces as provided in 1315.03–b, c.

(10) Stationary heating appliances above 150 volts to ground as provided in 1316.06–a.

(11) Motor frames, track and frame of electrical cranes as provided in 1330.08–a.

(12) Elevators as provided in 1331.04–a to d.

(13) Equipment in hazardous locations as provided in 1332.03–p, 1332.04–m and 1332.05–m.

(14) Equipment in garages as provided in 1333.08–a.

(15) Equipment in motion picture studios as provided in 1334.02–i.

(16) Signs and troughs for outline lighting, as provided in 1338.06–a.

(17) Equipment in theatres as provided in 1339.01–d.

(18) Vacuum and inert-gas systems as provided in 1350.02–e.

(19) Apparatus on systems of over 600 volts.

(20) Transformer cases except instrument transformers as provided in 1350.05–c.

(21) X-ray apparatus as provided in 1350.12–g.

b. Metal enclosures and covering for conductors, and separate grounding wires run in wire assemblies with the circuit conductors, are considered as suitable grounding conductors for protective grounding of fixed equipment when installed and used in compliance with the requirements of this Section and Section 130.5 of this Code.

c. A separate grounding conductor, if used for grounding fixed equipment, shall be installed as provided in Order 1309.07.

d. The point of attachment of the grounding conductor shall be accessible.

Order 1309.06. Grounding Portable Equipment.

a. The following exposed non-current carrying metal parts of portable equipment shall be grounded:

(1) Portable motors which operate at more than 150 volts to ground as provided in 1310.03–l.

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

(2) Portable lamps or other portable current consuming devices in hazardous locations as provided in 1332.03–m and o, 1332.04–l to n and 1332.05–l and m.

b. Metal enclosures and coverings for conductors, and separate grounding wires run in wire assemblies with the circuit conductors, are considered as suitable grounding conductors for protective grounding of portable equipment when installed and used in compliance with the requirements of this Section and Section 130.5 of this Code.

c. A separate grounding conductor, if used for grounding portable equipment, shall be installed as provided in Order 1309.07 of this Section.

d. The point of attachment of the grounding conductor shall be accessible.

Order 1309.07. Grounding Conductors.

Order 1309.08. Grounding Connections.

The material in these orders is covered in 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. Machines shall be provided with suitable drip pans if required by the authority enforcing this code.

b. 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.

c. If terminal blocks are used they shall be composed of approved non-combustible, non-absorptive insulating material, such as slate, marble or porcelain.

d. Where the wiring to fixed motors is accessible to unqualified persons and is in conduit, armored cable, metal raceways or similar construction, terminal enclosures or housings of substantial metal construction shall be provided at the motor terminals. The conduit, armored cable or metal raceways shall be mechanically and electrically connected to the terminal enclosures or housings. The terminal enclosures or housings shall be of ample size to properly make connections.

e. Soft rubber bushings may be used to protect lead wires where they pass through the frame, provided they will not be exposed to oils, grease, oily vapors or other substances having a deleterious effect on rubber. Where so exposed, bushings composed of porcelain, micanite or hardwood treated with a preservative shall be used.

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.

c. If a generator not electrically driven supplies a 2-wire grounded system the protective device shall be so placed as to disconnect the generator from all wires of the circuit.

d. 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.

e. 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, overload 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.

f. The frame shall be grounded in the manner prescribed in Section 130.9 if the generator operates at a voltage in excess of 150 terminal volts and is accessible to other than qualified persons. Where the frame is not grounded, it shall be permanently and effectively insulated from ground.

g. Each generator shall be provided with a name-plate giving the maker's name, the rating in kilowatts, if direct current, or kilovolt-amperes, if alternating current, the normal volts, and amperes corresponding to the rating, and the revolutions per minute.

Order 1310.03. Motors.

a. Motors shall not be operated in series-multiple or multiple-series except on constant-potential systems where permission has been granted by the authority enforcing this code.

b. For installation of motors in hazardous and extra hazardous places, see Section 133.2.

c. Each motor with its controller shall be provided with

a separate disconnecting means, except as provided below. The disconnecting means shall be of such design and so installed that when it is in the open position it will disconnect both the controller and the motor from all ungrounded supply wires. In the following cases a single disconnecting means may serve a group of motors.

(1) Motors which drive the several parts of a single machine or apparatus, such as cranes, hoists, metal and woodworking machines, etc. (See Section 133.0.)

(2) Groups of small motors under the protection of one set of automatic overload protective devices, as permitted elsewhere in the Code.

(3) Groups of motors in a single room within sight of the disconnecting means.

(4) Motors which are each controlled by a switch alone.

d. For connected loads of 50 H. P. and less, and also where the controller does not open all ungrounded main leads to a motor, a motor-circuit switch shall be used as the disconnecting means, except that a plug connector may be used with portable apparatus. For larger loads, where the controller opens all the ungrounded wires and all auxiliary circuits are fused, a disconnecting switch may be used. For a smaller motor, where permitted by the authority enforcing this code, plug fuses may serve as the disconnecting means. For motors controlled solely by a knife or snap switch, the disconnecting means may be at the distribution center.

By main leads to the motor is meant all armature circuits (not including shunt-field circuits) in the case of D. C. motors, and all primary leads (not including the secondary leads of slip-ring motors or the field leads of synchronous motors) in the case of A. C. motors.

e. The disconnecting means shall be of the indicating type, and in its open position make all ungrounded conductors of the controllers and motor "dead". One pole of the motor controller and one pole of the disconnecting means may be placed in a permanently grounded conductor of circuits supplying current to motor, provided these devices are so designed that the pole in the grounded conductors cannot be opened without opening simultaneously all of the conductors of the circuit. The disconnecting means shall have a continuous duty rating of at least 115% of the nameplate current rating of the motor and be located within sight of the controller or arranged to be locked in the open position.

f. A single-pole switch may be used as a controller in an ungrounded wire of a 2-wire motor not larger than ¼ H. P. operating at not more than 300 volts.

g. A motor and its driven machinery shall be within sight of the point where the motor is controlled, unless permission to locate the control point elsewhere is given by the authority enforcing this code. For exception see Section 133.2.

Note: If the motor and its driven machinery are not both within sight from a point at which the control equipment can be located, the placing of the control equipment within sight of the machine being driven will comply with the intent of the order. In such case provision shall be made for the locking of the disconnect switch in the open position, or an additional disconnect switch shall be provided within sight of the motor.

h. 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.

i. Adjustable-speed motors, if controlled by means of a field regulation, shall be so equipped and connected that they cannot be started under weakened field, unless this safeguard is incorporated in the design of the machine.

j. The control circuits of electrically operated speed-limiting devices and remote-control switches shall be in conduit.

k. Alternating-current motors operating freight or passenger elevators or cranes that are dependent on phase relation for the direction of rotation shall be protected by approved automatic circuit-breakers (or reverse-phase relays) operative in the event of any phase reversal that would cause a reverse motor rotation, or in the event of the motor being connected to the line single phase.

l. The frame, except for portable motors, shall be grounded if the motor operates in excess of 150 volts and is accessible to other than qualified persons. When the frame is not grounded it shall be permanently and effectively insulated from the 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 portable motors which operate at less than 150 volts be grounded when this can be readily accomplished.

m. Each motor shall be provided with a nameplate giving the maker's name, the rating in volts and amperes, including those for the secondary of a slip-ring-type motor,

the normal full-load speed and the interval during which it can operate, starting cold. The time interval given shall be either 5, 10, 15, 30, 60 or 120 minutes, or continuous.

Order 1310.04. Control Apparatus.

a. Control apparatus, other than auto-transformers, shall conform to the requirements of Sections 131.2 and 131.7 of this Code.

b. The control apparatus shall have a continuous-duty rating of not less than 115% of the name-plate current rating of the motor.

Order 1310.05. Auto-Transformer Starters.

a. Auto-transformer starters shall have no exposed live parts unless in suitable separate enclosures.

b. Cases for coils or switches shall afford access to the interior for inspection and oil renewal, and shall be so constructed that when mounted on a plane surface the case will make contact with such surface only at points of support. An air space of at least ¼ inch shall be maintained between case and surface.

c. The oil tank shall be marked in a suitable manner to indicate the proper oil level. When such device carries a visual oil indicator, the marking shall be for the proper oil level, with the starter assembled. If the visual indicator is not used, markings shall indicate the oil level prior to assembling.

d. The switch shall provide an off position, a running position and at least one starting position. It shall be so designed that it cannot rest in a starting position, or in any position which will render inoperative the overload protective devices in the circuit.

e. Cases for coils and switches of auto-transformer starters shall be grounded as required in Order 1309.05 of Section 130.9 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, or outside and adjacent to a building they shall be contained in an enclosure of fire-resistive material not communicating with the building except through openings closed by means of approved tight-fitting fire doors. When attached to a building they shall be separated therefrom by substantial supports. This paragraph shall not apply to transformers in central stations and substations.

Exception: (1) 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.

(2) The requirement for the transformer vault may be waived in case of transformers of not more than 5 K. V. A. capacity.

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, somewhat larger than the transformer.

c. The foregoing paragraph b shall not be construed to apply to bell-ringing and other signaling transformers which operate at a primary voltage not exceeding 250 volts.

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 130.9.

SECTION 131.2. SWITCHES

Order 1312.01. Open Knife Switches.

a. The spacing given in Tables 1 and 2 below, shall be considered standard and as the minimum allowable, except as otherwise provided for in this section.

TABLE 1

Spacings Between Parts of Opposite Polarity and Break Distances Within the Area Bounded by Contact Parts of the Switch Mechanism

Voltage	Amps.	Spacings—Inches		Fuses	Marking
		Opposite Polarity	Break Distance		
I. 125 V. DC or AC for switchboards and panelboards only.	30	1	¾	With or Without	—A. 125 V.
	60	1¼	1		
II. 125 V. DC or AC	30	1¼	1	With or Without	—A. 125 V.
	60	1½	1¼		
	100	1½	1¼		
	200 and *300	2¼	2		
	400 and 600	2¾	2½		
	800 to 6000 incl.	3	2¾		
III. 250 V. DC or AC	30	1¾	1½	With or Without	—A. 250 V.
	60	2¼	2		
	100	2¼	2		
	200 and *300	2½	2¼		
	400 and 600	2¾	2½		
	800 to 6000 incl.	3	2¾		
IV. For both 250 V. DC and 500 V. AC **	30	2¼	2	Without	—A. 250 V. DC, 500 V. AC.
	60	2¼	2		
	100	2¼	2		
	200 and *300	2½	2¼	**	
	400 and 600	2¾	2½		
	800 to 6000 incl.	3	2¾		
V. 500 V. AC	Same as in IV.			With	—A. 500 V. AC
VI. 600 V. DC or AC	30	4	3½	With or Without	—A. 600 V.
	60	4	3½		
	100 to 6000 incl.	4½	4		

Triple-pole switches with 125-volt spacings between blades for use on three-wire systems having 125 volts between adjacent wires and not over 250 volts between outside wires shall be spaced as in II and be marked –A. 125V.

Triple-pole switches with 250-volt spacings between blades, for use on three-wire systems having 250 volts between adjacent wires and not over 500 volts between outside wires, shall be spaced as in III, except 30-ampere fused switches to be spaced as in IV; they shall be marked –A. 250V and if equipped with fuses, fuses shall be of the 600 volt classification.

* The 300-ampere switches, with spacings of the 200-ampere switches, may be used only on switchboards.

** 250-volt D. C. fused switches of 100-ampere and greater capacities differ from 500-volt A. C. fused switches of the same capacities only in the spacings of their fuse clips, and therefore, such switches, when shipped unmounted, may be marked with the double voltage rating given in line IV of the table.

TABLE 2

Spacing Between Parts of Opposite Polarity Outside the Area Bounded by the Contact Parts of the Switch Mechanism (Except for Link Fuses)

When Mounted on Same Surface	When Clear of Surface
Not over 125 V. ¾ inch	½ inch
Not over 250 V. 1¼ inch	¾ inch
Not over 600 V. 2 inch	1 inch

It is recommended that switches above 1,000 amperes capacity be not used to break currents, but only as disconnecting switches.

b. Cutout-bases shall satisfy the appropriate provisions of Section 130.8 of this Code.

c. Switches rated above 600 amperes at 600 volts and 600 amperes at 250 volts, and therefore exceeding the capacities of standard sizes of cartridge enclosed fuses, may be arranged for fuses in multiple, provided as few fuses as possible are used, and the fuses are of equal capacity, and the multiple terminals for each pole are mounted in common.

d. Switches marked with the combined rating, 250 volts, D. C. or 500 volts, A. C. shall not be provided with fuse terminals.

e. Switches having fuse terminals and intended for use in ungrounded branch circuits shall have fuse terminals in each pole.

f. 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 from 200 to 1000 amperes, inclusive.

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 enclosed in approved metal boxes or cabinets, and shall be of the externally operable type.

b. Except as provided in paragraph d of this order, switches or manually operated circuit-breakers shall be

placed only in dry, accessible places, and be grouped as 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. Enclosures 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 130.9 of this Code.

e. All switches shall be of the enclosed 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.

Note: The intent of this order is to require an individual switch or other disconnecting means to disconnect each set of cartridge fuses.

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.

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–l) 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 horse power or less need not have their starters so equipped.

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. Switches, when installed, shall disconnect all ungrounded wires of the circuit which they control.

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. On constant-potential circuits, all service switches and all switches controlling circuits supplying current to motors or heating devices, unless otherwise provided in this code, shall be so arranged that the opening of the switch will disconnect all the ungrounded wires.

d. Where a circuit-breaker serves as a switch, it shall conform to the requirements of this order as to the number of poles.

Order 1312.05. Mounting of Snap Switches.

a. Sub-bases of non-combustible, non-absorptive 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 enclosed in a box constructed of iron or steel, in addition to the porcelain enclosure 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 enclosed 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, 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 substantial flameproof outer covering.

e. Flameproofing 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 overload protective devices of a rating not larger than 15 amperes except that for ratings of two amperes or less special enclosed 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 service switches, 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, enclosed 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 enclosed in approved weatherproof cabinets.

g. Panelboards and cut-out bases for lighting distribution centers shall be enclosed in metal cabinets and the combination of cabinet and enclosed 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.

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, wire-ways shall be lined with metal unless approved armored conductors with suitable fittings are used. This requirement shall not apply to wireways in glass, marble or similar non-absorptive non-combustible insulating material.

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. All fixtures shall, where practicable, be sufficiently ventilated. All forms of fixtures in which the wiring is liable to be exposed to temperatures in excess of 120° F. (49° C.) shall be so designed or ventilated and installed as to operate at temperatures which will not cause deterioration of the wiring.

h. Canopies and outlet boxes shall, taken together, provide ample space for the reception of the wires and their connecting devices.

i. Receptacles having exposed terminals shall not be placed in canopies unless completely enclosed in metal.

j. 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.

k. 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 enclosed 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.

It is recommended that approved splicing devices or approved plug connections be used for attaching the fixture wires to the circuit wires.

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. 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 Section 130.2 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. Approved fixture wire, approved flexible cord or approved rubber covered wire shall be employed, unless the wiring is exposed to temperatures in excess of 120° F. (49° C.) in which case conductors having slow-burning or other heat-resisting covering shall be used. All fixtures in dry places designed for or used with Mogul base lamps shall be considered as being exposed to these high temperatures. Fixtures intended for outdoor use shall be wired with approved rubber-covered conductors. Wire shall always be so disposed as to avoid exposure to high temperatures as far as practicable. Fixtures intended for use in rooms where flammable gases may exist shall consist of rigid stems, internally wired with approved rubber-covered conductors, soldered directly to the circuit wires, and shall be equipped with vapor-tight globes.

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. Fixtures on circuits above 150 volts to ground and all 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 Order 130.9, 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 Order 130.9 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.

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.

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 pendant 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, especially approved for the location, shall be employed in damp or wet places or where corrosive vapors exist. If not attached to fixtures, they shall be hung from separate stranded wires not less than No. 14, which are soldered directly to the circuit wires, but supported independently thereof.

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–g of this code.

e. Flush receptacles shall be enclosed in approved metal boxes in addition to the insulating enclosure of the receptacle mechanism.

f. Attachment plugs and receptacles located in floors shall be enclosed 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.

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 enclosed 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 overload 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 overload circuit-breaker may be used in place of both the protective device and the switch.

Order 1315.03. Mercury-Vapor Lamps.

a. Enclosed mercury-vapor lamps shall be equipped with only such resistances or regulators as are enclosed in noncombustible cases, such resistances or regulators being treated as sources of heat.

b. Except as provided below, branch circuits supplying mercury-vapor lamps shall satisfy the provisions of paragraph f of Order 1308.07 of this Code.

(1) Branch circuits supplying only mercury-vapor lamps shall have the wires protected by fuses or other approved overload protective devices having a rated capacity not greater than

40 amperes ---------- at 125 volts or less
20 amperes ---------- at 126 to 250 volts

(2) A group of mercury-vapor lamps wired in parallel and mounted on a single frame, the total capacity of which does not exceed 4000 watts, may be used, if supplied by a separate branch circuit having a suitable automatic overload protective device in each ungrounded conductor.

c. Exposed metal parts of such lamps or fixtures shall be grounded, as provided for equipment in Section 130.9 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.

Order 1316.02. Special Provisions for Branch Circuits.

For the purposes of this order, the several types of branch circuits serving electrical appliances are further defined as follows:

Lighting Branch Circuits are circuits supplying energy to lighting outlets only.

Combination Lighting and Appliance Branch Circuits are circuits supplying energy to both lighting outlets and appliance outlets.

Ordinary Appliance Branch Circuits are circuits supplying energy to either permanently wired appliances or to attachment plug outlets, i. e., appliances or convenience outlets, or to a combination of permanently wired appliances and attachment plug outlets on the same circuit; such circuits to have no permanently connected lighting fixtures. These circuits are equipped with attachment plug receptacles and plugs rated at not over 15 amperes, 125 volts; 10 amperes, 250 volts; and may have wire of No. 14 gauge and be fused at 15 amperes.

Medium-Duty Appliance Branch Circuits are similar to Ordinary Appliance Branch Circuits but are wired with No. 10 wire and fused at 25 amperes. They are limited to 125 volts.

Heavy-Duty Appliance Branch Circuits are 2-wire branch circuits derived from a 125–250 volt grounded-neutral interior wiring system supplying energy to fixed or portable electrical appliances. They consist of No. 10 wire and are fused at 25 amperes. Where attachment plug receptacles and plugs are used for connecting devices to such circuits they must be rated at not less than 20 amperes, 250 volts.

a. Branch circuits, other than lighting branch circuits and except as the provisions of Order 1308.08 of Section

130.8 or other special orders of this code apply, shall be of a type and number competent to supply electrical appliances according to the following sub-paragraphs, 1–5 inclusive.

(1) One or more portable electrical appliances, each rated at 6 amperes or 660 watts or less, may be used on lighting branch circuits or on combination lighting and appliance branch circuits.

(2) One or more fixed or portable electrical appliances, each rated at not over 1320 watts, may be supplied by an ordinary appliance branch circuit.

(3) One or more fixed or portable electrical appliances, each rated at not over 15 amperes or 1650 watts and not over 125 volts, may be supplied by a medium-duty appliance branch circuit.

(4) One or more fixed or portable electrical appliances, each rated at not less than 15 amperes or 1650 watts and at not more than 20 amperes, may be supplied by a heavy-duty appliance branch circuit.

(5) Each fixed or portable electrical appliance rated at more than 20 amperes shall be supplied by an individual branch circuit and shall be controlled as provided in paragraph a of Order 1316.03 of this section. Sub-division of the load by units within an appliance shall not be taken as a basis for determining the character of the circuit supplying a multi-unit appliance.

For number of outlets on circuits according to Nos. 1–4, inclusive, above, see paragraph g of Order 1308.07 of Section 130.8 of this Code.

In locations where appliances larger than 6 amperes capacity are likely to be used, as in working spaces, it is recommended that Medium-Duty Appliance Branch Circuits shall be installed.

It is recommended that each room be provided with at least two attachment plug receptacles located at different points in order to render unnecessary use of long extension cords and the plugging of portables into lamp holders.

b. Conductors of branch circuits which supply only cooking and baking appliances rated at over 1650 watts may be of capacities determined according to sub-paragraph 3–(15) of paragraph d of Order 1306.13 of Section 130.6.

Order 1316.03. 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 1316.04. Wires Supplying Electrically Heated Appliances.

a. Wires supplying stationary electrically heated appliances shall, if not in conduit, be so located as to be 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, Type H. For other portable electrical heating appliances approved lamp cord, Type C, or other cord specially approved for the purpose may be used.

Order 1316.05. 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 and used 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 such electrically heated appliance or group of such electrically heated appliances shall be used with an approved signal, unless the appliance is provided with 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 enclosed 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 1316.06. Grounding.

(a) Metal frames of stationary electrically heated appliances, operating on circuits above 150 volts to ground, shall be grounded in the manner specified in Section 130.9 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 of the slow-burning type. For large rheostats, and similar resistances where the contact devices are not mounted up-

on them the connecting wires having slow-burning insulation may be so arranged in groups that the maximum difference of potential between any two wires in any group shall not exceed 75 volts. Each group of wires shall either be mounted on non-combustible, non-absorptive insulators giving at least ½ inch separation from the surface wired over, or, especially where it is necessary to protect the wires from mechanical injury, each group of wires may be encased in flexible tubing and placed in approved conduit, the flexible tubing extending at least 1 inch beyond the ends of the conduit.

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 ⅛ 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 ½ 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 enclosed in approved metal boxes or cabinets.

Order 1317.03. Lamp Resistances.

a. 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.

b. When used as resistance, lamps 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 name plate, which shall be permanently attached beside the porcelain receptacle or receptacles and stamped with the wattage or voltage of the lamp or lamps to be used in each receptacle.

c. 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. Wiring and appliances supplied by storage batteries shall be subject to the general requirements of this code which apply to wiring and appliances fed from generators developing the same difference of potential.

For battery installations for small isolated plants of less than 50 volts, see Section 134.0 of this Code.

Order 1318.02. Special Requirements.

a. The battery room shall be thoroughly ventilated.

b. Wiring shall be enclosed 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 insulations on conductors shall not be permitted.

c. Storage batteries shall be mounted on non-absorptive, non-combustible insulators, such as glass or thoroughly vitrified glazed porcelain.

d. Metal susceptible to corrosion unless suitably protected against attack from acid or acid spray, shall not be employed in the cell connections of storage batteries.

SECTION 131.9. LIGHTNING ARRESTERS

Order 1319.01. In Stations.

Requirements for these installations are given in Part 1 of this code.

Order 1319.02. Radio Equipment.

See Part 5 of this code.

Order 1319.03. Signal Systems.

See Section 136.0 of this code.

Order 1319.04. Grounding.

See Section 130.9 of this code.

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 131.9, 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 be no smaller than No. 12.

c. Slow-burning wire shall be employed only between resistance and contact plates of rheostats or where exposed to severe external heat. Wires between resistances and contact plates shall conform to the requirements of Order 1317.01, paragraph h, of this Code, except that such wires, if exposed to moisture, shall be of the rubber-covered type.

Order 1330.03. Installation of Wires.

a. Exposed wiring, other than collector wires, shall be supported 1 inch from the surface wired over, 2½ inches apart for voltages up to 300, and 4 inches apart for voltages between 301 and 600; provided, however, that in dry places where space is limited each wire may be separately encased in approved flexible tubing securely fastened in place.

b. Wiring not in conduit, other than collector wires, and whether on crane or hoist, shall be isolated beyond normal reach of operators or other persons and out of normal reach of tools and materials being handled.

Order 1330.04. Collector Wires.

a. Collector wires 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 insulating supports placed at intervals not exceeding 20 feet. When run horizontally, such wires shall be separated not less than six inches; when run otherwise, not less than eight inches. Where necessary, intervals between insulating supports may be increased up to 40 feet, the separation between wires being increased proportionally. 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 50 feet, insulating saddles shall be placed at intervals not exceeding 30 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. 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.

f. Monorail runway conductors on I-beam or equivalent structural runways shall have a minimum horizontal spacing of 2½ inches between conductors and a minimum clearance of 1½ inches from grounded metal parts, if a wire is used for the conductors, or 1 inch if steel bars or shapes are used.

g. Remote control collector wires or conductors when carried along runways shall be considered as coming under the classification of Bridge collector wires.

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 1 of Order 1332.05 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 with its leads shall be separately protected by a cutout 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 cutout. 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. A limit switch shall be provided for the upper limit of travel of crane hoists.

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 enclosing 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 130.9 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. The flexible or traveling cables of the operating control and lighting circuits shall be of approved Type E or Type S cord, as specified in Order 1306.09, Section 130.6 of this Code. Where attached to the car they shall run in approved rigid conduit, securely fastened in place and properly bushed.

Exception: Sections of flexible conduit not more than three feet long in any case may be used where short bends or difficult connections are necessary.

b. Conductors for lighting cables shall not be smaller than No. 14 and for control cables shall not be smaller than No. 16.

c. No conductor smaller than No. 14 shall be used for any elevator operating, control, power or car lighting circuit except as provided above for lighting and control cables and as otherwise provided in this code for fixture work.

d. No conductor smaller than No. 16 shall be used for any elevator signal circuit except those receiving energy from primary batteries or approved bell-ringing transformers. When No. 16 conductor is used it shall be protected by not larger than 6-ampere fuses.

e. Conductors, other than lighting and control cables, where located in hoistways shall be encased in approved rigid conduit, provided that flexible conduit or armored cable may be used between riser and limit switch, interlocks, push buttons or similar devices. Split tees and elbows may be used on exposed conduit work except where the pipe contains feeders. For control circuits the number of wires installed in a conduit 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. Elevator circuits, except signal wires receiving energy from primary batteries or approved bell-ringing transformers, shall be installed in approved conduit equipped with approved terminal bushings having an individual outlet hole for each wire; provided that, for more than 8 wires the conduit may be terminated with an insulating bushing and the wires bunched, taped and painted with an insulating paint. The conduit shall terminate as close to the wire terminals as convenience in handling will permit, but in no case closer than six inches to the floor.

h. 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, conduit, pull box or junction box 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 conduit system and the equipment is insulated from ground for this maximum voltage.

i. Where the current characteristics within the system are changed, the wires shall not be run in the same traveling cable, conduit, junction box or pull box, except on the car, at the control boards, floor selectors, hatchway junction boxes and at similar points where it is impracticable to separate such wires.

j. 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 conduits.

k. 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.).

l. All wires between main circuit resistances and the back of control panels shall each have a flameproof outer covering, as prescribed in Order 1317.01, paragraph h, of this Code. All other wiring on control panels may be of the rubber-covered type, provided the wires are held in such a manner as to be immovable and free from mechanical injury, and are not subjected to a temperature exceeding 120° F. (49° C.).

m. Wires having type SB insulation or groups of wires covered with a flameproof tape shall not be used as connections for the operating circuits of elevator controllers.

Note: Type SB flameproof coverings when damp may carry enough current to cause controllers to function incorrectly and this incorrect functioning may be a life hazard.

n. 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.

o. 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. A manually operated fused switch disconnecting all 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 level.

c. Each new single belt drive 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 enclosures 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. The hand-operated rope (shifting cable) need not be grounded if provided with approved strain insulators.

Order 1331.05. Live Parts.

a. All live parts of electrical apparatus in or on elevator cars or in elevator hoistways shall be suitably enclosed 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 enclosure 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. If the wiring is on the back of the controller panel there shall be a clear space of at least 24 inches back of the apparatus on the rear of the controller panel and at least 18 inches on the sides of a bank of controller panels, and on at least one side of a single panel. There shall also be at least three feet of clear space in front of the controller.

This rule shall not be interpreted to forbid the enclosing of the rear of control panels in steel cabinets, but when such cabinets are used there must be a clear space of at least 24 inches back of the apparatus on the rear of the controller panel when the back of the steel 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.

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.

Order 1332.02. General.

a. The requirements of this section shall be considered additional or amendatory to those prescribed in Sections 130.1–131.9 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. Service entrance equipment, and all panelboards and switchboards shall not be installed.

c. Rigid conduit made up with joints and fittings approved for use in explosive atmospheres shall be the wiring method employed.

d. Fuses shall not be installed. 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.

Motors located outside of paint-spray booths and judged by the authority enforcing this code to be outside of the hazardous area may be of any standard totally-enclosed type or of the open induction type having no brushes, make-and-break contacts, collectors, or other arcing or sparking parts.

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 contractors located at a point where the hazardous conditions of this class do not prevail, auxiliary control push buttons or switches of the oil immersed or vapor-tight type 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 enclosed 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.

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 enclosed 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 non-combustible, non-absorptive, moulded composition type with no exposed metal parts, and shall be of the keyless type.

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 enclosure 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 non-current 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 Orders 1309.05 to 1309.08 of Section 130.9 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 enclosed 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 enclosed 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.

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 enclosed in substantial dust-tight housings or shall be of the totally enclosed, enclosed-fan-ventilated, or enclosed-pipe-ventilated types or shall be enclosed 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 enclosed, enclosed-fan-ventilated, or enclosed-pipe-ventilated types.

f. When motors of the enclosed pipe-ventilating type are used, or when motors are enclosed 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. 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-enclosed, enclosed-fan-ventilated, or enclosed-pipe-ventilated types, or shall be enclosed 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.

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 enclosed 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 enclosed 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, enclosed 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 enclosed 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 an explosion-proof or a vapor-proof enclosure 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. The exposed non-current 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 Order 1309.05 to 1309.08 of Section 130.9 of this Code. The lock-nut-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.

o. 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 enclosed 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 enclosed in dust-tight metal cases or cabinets. Circuit-breakers shall be of the dust-tight oil-immersed type, or shall be enclosed in dust-tight metal cases.

d. Rigid conduit shall be the wiring method employed.

e. If motors or generators having brushes or sliding contacts are used they shall:

(1) be of the totally enclosed, enclosed fan ventilated, or enclosed pipe ventilated types, or

(2) be enclosed in separate rooms or housings built of non-combustible materials, so constructed as to adequately exclude flyings or lint, and properly ventilated from a source of clean air, or

(3) have brushes or sliding contacts enclosed in substantial tight, metal housings, or

(4) have upper half of brush or sliding contact end of motor enclosed by wire screen of not less than No. 14 mesh and lower half enclosed by solid metal covers.

f. When motors of the enclosed pipe-ventilating type are used, or when motors are enclosed 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 enclosed 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 enclosed 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 enclosed 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 enclosed 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. 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 the 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.

n. The exposed non-current 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 Orders 1309.05 to 1309.08 of Section 130.9 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.

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 131.9, 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.

Order 1333.02. Wiring.

a. Where floor area is sufficient to permit the storage of more than two vehicles, the building must meet the build-

ing 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 shall be located at least 4 feet above the floor, except in a room separated by a partition from the garage proper.

c. Approved reinforced cord shall be used for pendant 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. Where spark-producing devices are not located at least 4 feet above the floor, or placed in vaporproof enclosures, switchboards and charging panels shall be located in a room or enclosure 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-enclosed 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-enclosed type, have wire screens of not less than No. 14 mesh placed at commutator or brush ends to prevent the falling of particles.

Order 1333.07. Special Precautions.

a. Cutouts, switches and receptacles shall be placed at least 4 feet above the floor.

b. 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 enclosures of equipments and the like shall be grounded when and in the manner prescribed in Section 130.9 of this Code. This shall apply to all devices except pendant 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 pendant 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

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 131.9, inclusive, of this code, but shall not be applied where only approved slow-burning (cellulose acetate or equivalent) film is used.

(22)

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. Approved conduit, metal raceway or armored cable shall be employed as the wiring method.

b. Side wall lamp outlets shall consist of receptacles enclosed in approved outlet boxes equipped with open-end guards riveted to the covers of the boxes.

c. Pendant 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 enclosed 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 enclosed to prevent accidental contact by persons and objects. All switches shall be of the externally operable type. Rheostats shall be placed in cabinets which enclose 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-enclosed, enclosed-fan-ventilated, or enclosed-pipe-ventilated types, or

(2) be enclosed in separate rooms or housings, built of non-combustible 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 enclosed by solid metal covers, or

(4) have brushes or sliding contacts enclosed in substantial, tight, metal housings, or

(5) have the upper half of brush or sliding contact end of the motor enclosed by a wire screen of not less than No. 14 mesh and the lower half enclosed by solid metal covers, or

(6) shall have wire screens of not less than No. 14 mesh placed at the commutator or brush ends.

i. All conduit, armored cable or metal raceways, exposed metal frames, and enclosures or equipment shall be grounded as prescribed in Section 130.9 of this Code. This shall apply to all devices, except pendant and portable lamps operating at not more than 150 volts to ground.

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 enclosed or otherwise guarded to prevent accidental contact of persons or objects.

e. All conduit, armored cable, metal raceways, exposed metal frames and enclosures of equipment shall be grounded as prescribed in Section 130.9 of this Code. This shall apply to all devices except pendant and portable lamps operating at not more than 150 volts to ground.

Order 1335.02. Projectors of Professional Type.

a. The arc-lamp house shall be composed entirely of metal having a thickness not less than No. 24 U. S. sheet metal gauge (.025 inch) except where the use of approved insulating material is necessary. Details of construction shall conform to the requirements of Order 1315.01, of this Code. An incandescent-lamp inclosure shall conform to the above requirements so far as may be practicable.

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. Enclosure 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.

b. 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-paragraphs 1–6 inclusive of paragraph h of Order 1334.02 shall be considered as providing the required protection.

Order 1335.04. Projectors of Non-Professional Type.

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 incandescent 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. ORGANS

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 131.9 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 1336.02. 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 130.9 of this Code.

Order 1336.03. 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 enclosed 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 or the slow-burn-

ing type 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 1336.04. 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 enclosures 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 1336.05. 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 133.7. RADIO EQUIPMENT

The material in this section will be found in Part 5.

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 131.9, inclusive, of this Code.

b. Signs and outline lighting which employ vacuum or inert-gas tube systems shall, in addition to requirements of this section, comply with the provisions of Order 1350.02 of Section 135.0 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, treated with at least three coats of anti-corrosive paint, 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.

c. The design shall be such as to afford ample strength and rigidity, to enclose 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. One or more accessible approved boxes or cabinets shall be provided to contain cutouts, flashers, or other similar devices placed on or within the body or structure of a sign or on or in a building. If outside of a building such boxes and cabinets shall be weatherproof. Non-weatherproof transformers if outside buildings shall be placed in such a box or cabinet.

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 if for sign use 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, and not smaller than No. 14, shall be used.

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.

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 outside of sign structure or outline wiring, except as provided in Order 1338.05 of this section, shall be enclosed in approved conduit, metal armor, or metal troughs. Outside a building where conduit work is used, it shall be made weatherproof and where armor is employed an approved lead sheath shall be placed over the wire insulation.

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 enclosed 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 130.9 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. 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. THEATERS; INCLUDING MOTION-PICTURE HOUSES

(See also State Building Code)

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 131.9, 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.

c. Emergency lights shall be deemed to be exit lights, and all lights necessary to illuminate lobbies, stairways, corridors, passageways, aisles, and other portions of the theater to which the public has access, which are normally kept lighted during the performance, to enable the public to leave the building safely in case of emergency.

d. Where conduit, armored-cable or metal raceway construction is employed, all such conduit, metal sheath, raceways, all exposed metal frames and enclosures of equipment, including borders, shall be grounded as prescribed in Section 130.9 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.

Order 1339.02. Services.

a. Where the supply can be obtained from two street mains, two or more separate and distinct services shall be installed; one service shall be of sufficient capacity to supply current for all emergency lights, and the other service or services shall be of sufficient capacity to supply the normal demand of the theater equipment and sufficient lights to provide equivalent illumination to that of the emergency lights; or the emergency lights shall be suitably sub-divided between two or more of the services to enable emergency illumination to be maintained in case of interruption of one of the services. Where the supply cannot be obtained from two separate sources, the feed for the emergency lights shall be taken from a point on the street side of the main fuses.

b. Where the source of supply is an isolated plant located in the building, an auxiliary service of capacity sufficient to supply all emergency lights shall be obtained from some outside source, or from an adequate storage battery installed upon the premises.

c. Where a source of supply at less than 50 volts is employed for one or more lighting systems in the premises, the installation shall also comply with the appropriate provisions of Section 134.0 of this Code.

Order 1339.03. Auditorium.

a. Approved conduit, metal raceway or armored cable shall be employed as the wiring method.

b. Receptacles shall be enclosed 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 enclosed in approved cabinets.

Order 1339.04. Stage.

a. Approved conduit 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 enclosed 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 slow-burning wire shall be used for wiring the border.

i. Stage and gallery receptacles shall be in approved pockets or enclosures 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 enclosed 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 enclosed 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 enclosed in a suitable iron box having a tight, self-closing door.

Order 1339.05. Dressing Rooms.

a. Approved conduit 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 1339.06. 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 enclosed in a substantial properly ventilated metal case affording a clearance of at least 1 inch between case and resistance element. If the rheostat is mounted on the standard, a clearance of 3 inches above the floor shall be maintained.

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 1339.07. 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 1339.08. Portable Strips.

a. Portable strips shall conform to the requirements of paragraphs d, e, and f of Order 1339.04, 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 1339.09. 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 enclosed 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 1339.10. 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 1339.11. 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 1339.12. String or Festooned Lights.

a. Joints in wiring shall be staggered where practicable.

b. Lamps enclosed in lanterns or similar devices shall be equipped with approved guards.

Order 1339.13. 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.

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 131.9, 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 circuits or frames of engine or generator shall not be required.

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 131.9, inclusive, 133.2 and 133.8 of this Code.

Order 1350.01. Series Arc Lighting.

a. 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. Vacuum and Inert-Gas Tube Systems.

a. The tube shall be substantially supported and so installed as to be free from contact with flammable material or grounded metal objects. It shall not be unduly exposed to mechanical injury. The tube terminals shall (1) project within the sign enclosure, or (2) shall be isolated from combustible material and inaccessible to unauthorized persons, or else (3) shall be installed in separate enclosures 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.

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 cabinets unless placed within the metal enclosure provided for the complete assembly. The transformer secondary open-circuit voltage shall not exceed 15,000 volts.

c. High-voltage conductors shall be approved for the purpose and shall be not smaller than No. 14 B. & S. gauge. Outside of the cabinets and tube-terminal enclosures 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, they shall be run in conduit or on approved insulators which maintain a separation of at least two inches from other objects.

d. Not more than one transformer shall be dependent upon a single automatic overload 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. Enclosures 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 enclosures shall be permanently and effectively grounded in accordance with Section 130.9, except that a No. 14 wire may be used for bonding together isolated tube-terminal boxes or outline systems.

f. Enclosures for transformers, regulating coils and tube terminals shall, for indoor installations having live parts exposed within the cabinet, be arranged so that the door of the enclosure can not be opened without breaking the primary circuit.

Order 1350.03. Wiring.

a. Circuits operating at more than 7500 volts between conductors shall not (except as provided in Order 1350.02) be installed in buildings other than central station, substations, transformer vaults and fire-resistive motor rooms. Industrial substations for such voltages, if not outdoors or in a separate detached building, shall meet the requirements for a transformer vault in Order 1350.07.

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 consist of approved multiple-conductor, grounded metal-sheathed cable enclosed in approved conduit. Where the cable is not exposed to moisture, the metal sheath may be omitted by permission of the inspection department. Where moisture is absent, the metal sheath need not be continued over splices; but where the metal sheath is required 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. Open work may be employed in central stations, substations, generator, transformer and switching rooms and in motor rooms provided the wires are rigidly supported on glass or porcelain insulators which will keep them eight inches apart, except at apparatus and devices, and at least two inches from adjacent surfaces in all cases, and three inches where voltage exceeds 2500.

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. They shall enter the building only in rigid conduit or as separate individual wires. Open wires shall enter through waterproof insulating tubes or bushings, with drip loops on the outside. Where rigid conduit is used, it shall have weatherproof threaded joints and be equipped with an approved service pothead.

g. Underground service conductors shall be not smaller than No. 8, shall be lead-covered and if exceeding 2500 volts to ground shall terminate in suitable pot-heads or their equivalent located to conform with Order 1350.10. The end of underground service conduit shall be sealed with suitable compound.

Order 1350.04. 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 1350.05. 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 1350.07 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 enclosure of fire-resistive material large enough to provide an air space of at least 6 inches on every side of the transformers. This enclosure 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 130.9 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.

d. For oil-filled transformers which are not located in central stations or substations, the enclosure required by paragraph b of this section shall consist of fireproof vault construction in accordance with Order 1350.07 of this section.

e. For transformers in electric furnace rooms the requirements of this section and of Order 1350.07 of this section 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 1350.06. Control and Protective Equipment.

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 be separately controllable and protected by a manually operable circuit-breaker which interrupts all ungrounded circuit wires and which is automatically actuated by excessive overload in any ungrounded wire and the number of overcurrent units shall be as specified in the table of paragraph p of Order 1308.05; provided, that certain transformers installed in fireproof vaults may be otherwise controlled and protected when and as permitted by Order 1350.09 of this section. For the purposes of this rule, transformers operating in multiple shall not be considered as operating in bank and shall be separately protected. 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. Where the motor-starting device does not open all ungrounded leads to the motor, this circuit-breaker shall be installed in sight of the person operating the motor-starting device or else have provision for locking in the open position.

b. 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.

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 armor-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.

c. Switches and control apparatus on circuits exceeding 2500 volts to ground shall be installed in a vault complying with Order 1350.07, or in a fire-resistive switch room or motor room.

Safety control truck panels and armor-clad switchgear units are considered to comply with this rule.

d. All switches including disconnectors shall be so located that the point from which they are operated is safely accessible to qualified and authorized persons.

Order 1350.07. Transformer Vaults.

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 enclosed 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 enclosure.

b. The enclosure 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 shall be provided with automatic or manually controlled 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.

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 volt-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. Unless access is from outside the building only, the doorway to the vault shall be thoroughly closed by means

Kilo

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 4 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.

Order 1350.08. Capacitors (Static Condensers).

a. Capacitors of the type made up of small units, each of which contains less than three gallons of oil, may be installed in power houses or factory buildings if combustibles are kept well away from them. 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 which have all units in single tanks filled with oil shall be installed as required for transformers in Order 1350.05.

c. For transformers used with capacitors, the requirements of Order 1350.05 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 6 inches high which form a basin of sufficient capacity to retain all the oil contained in the transformers; and be protected by an automatic overload circuit-breaker (or other protective device and switch) set to operate at a current corresponding to not over 150% of the rated capacity of the capacitor.

Order 1350.09. Service Equipment.

Secondary conductors and not primary conductors are regarded as constituting the service wires to the building proper in the following cases, and where any one of the following conditions is satisfied only paragraphs (g), (h), (i) and (j) of this section apply.

(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 a transformer vault conforming to the requirements of Order 1350.07 and 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 over-current 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 7500 and more than 4000 between conductors, and where the transformer capacity does not exceed 50 k. v. a. per phase, the following protective devices shall be provided:

(1) An automatic oil circuit-breaker, or

(2) A non-automatic oil switch with approved fuses.

When the transformer capacity exceeds 50 k. v. a. per phase, an automatic oil circuit-breaker shall be provided.

c. On services entering fireproof transformer vaults, where the voltage is not more than 4000 between conductors and not more than 2300 between conductors and ground, and the transformer capacity does not exceed 50 k. v. a. per phase, the following protective devices shall be provided:

(1) An automatic oil-circuit-breaker, or

(2) A non-automatic switch with approved fuses, or

(3) Approved fuses, or

(4) An approved automatic air-break circuit-breaker.

When the transformer capacity exceeds 50 k. v. a. per phase, automatic oil circuit-breakers shall be used.

At the time of adoption of paragraphs b and c preceding, other devices to serve in lieu of oil circuit-breakers were not available. Such devices if developed and found suitable by the authority enforcing this code, may be employed in lieu of oil circuit-breakers and will satisfy the intent of this code.

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. Suitable circuit-breakers or switches 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 the above required primary protection, where consisting of an oil circuit-breaker manually operable from a point outside of any vault, will be considered as sufficiently protecting and controlling the secondary mains.

h. Air-break disconnectors and fuses shall be accessible to qualified attendants only. Air-break disconnectors required by this section shall be provided with means for grounding on the load side. Such grounding means need not be provided for duplicate disconnectors, if any, installed and maintained by the supply company.

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 (paragraph b in orders 1332.03, 1332.04, and 1332.05) of this Code.

Order 1350.10. Guarding Live Parts.

a. All live parts, including conductors, which are connected to circuits of more than 600 volts between conductors, shall be enclosed or isolated so as to be accessible to qualified persons only. These enclosures, if of metal, shall be grounded as prescribed for the grounding of equipment in Section 130.9 of this Code.

b. 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 1350.11. Outdoor Substation.

a. Where step-down transformers are located outdoors they shall be so placed as not to interfere with firemen, and not be accessible to unauthorized persons. Unless isolated by elevation, they shall be surrounded by a grounded metal

fence, and placarded with a warning sign which indicates the highest voltage involved. Overflow oil shall drain away from adjacent buildings and combustible material.

Order 1350.12. X-Ray and High-Frequency Apparatus.

a. Adequate mechanical barriers shall be provided to prevent too close approach to any high-voltage part except the operating tube and its leads, and it is recommended that all other parts be enclosed in a separate room or cabinet. Such barriers may consist of grounded metal or of insulating material such as glass. High-voltage parts enclosed in a wooden cabinet shall have adequate spacing from the wooden walls. 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.

b. Overhead high-voltage stationary conductors shall be not less than 7 feet 6 inches above the floor where the ceiling height permits and in no case less than 7 feet. 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. X-ray tubes used in therapy shall be mounted in a grounded metal enclosure.

c. 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.

d. Where more than one piece of apparatus is operated from the same high-voltage source, each shall be provided with a high-voltage switch so as to give independent control.

e. 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.

f. 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 1350.05 for power transformers.

g. All tube stands and fluoroscopes shall have their frames, operating handles, and other non-current-carrying metal parts of apparatus grounded in conformity with the requirements of Section 130.9. Non-metallic tables and chairs are recommended, particularly for therapeutic work. Metal or other conducting tables or chairs for supporting patients shall be suitable insulated from ground, and insulating floors, mats or platforms shall be provided for operators. It is recommended that floors of concrete or other conducting material be completely covered with linoleum, rubber tile or other insulating material.

SECTION 136.0. COMMUNICATION SYSTEMS

Order 1360.01. General.

a. The provisions of this section shall apply to telephone, telegraph (except radio), district messenger and call-bell circuits, fire and burglar alarms, and similar systems.

Note: Such protective measures as are essential to safeguard these systems under the various conditions to which they are subjected are outlined in these orders.

Order 1360.02. Outside Wires.

a. Outside wires shall be placed in underground ducts or strung on poles. They shall not be run across or attached to roofs except by permission of the authority enforcing this code.

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 interrupted close to the entrance to a building by an insulating joint or equivalent device.

Exception: Such insulating joint will not be required if the cable sheath is permanently and effectively grounded and to a water piping system if it is available.

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-sheath type may have paper or other suitable insulation. If the metal sheath is omitted each wire shall have 1/32 inch rubber insulation and the bunched wires shall be covered with a substantial braid.

g. Wires from the last outdoor support to the protector, and wires attached to buildings shall have 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 1/32 inch, but not less than 1/40 inch in thickness. Where not in conduit, such wires shall be separated from woodwork and supported on glass or porcelain insulators.

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 1360.03. 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 131.9, inclusive, of this Code. This transforming device shall be permitted only when the primary thereof is properly grounded as required in Section 130.9 of this Code.

Order 1360.04. 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 enclosed by streets and includes the alleys so enclosed but not any street.

Order 1360.05. 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 necessary 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 non-current-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 1360.06. 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 enclosing 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 non-current 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. (See rule 391)

(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 1360.07. 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	.06	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 enclosed, so as to prevent accidental contact therewith.

c. Enclosures shall be of non-combustible material; they shall completely enclose 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 enclosure 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 enclose 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 enclosed from floor to ceiling, in no case shall other conductors or equipment be within the same enclosure that shields the bare conductors. Portions of fire-resistive enclosure may serve as portions of this enclosure as under Paragraph (f). If this enclosure 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 in-

stallation. 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 Overload 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 enclosure, except that same may be carried to panel boards and the like, when mounted directly on the exterior of such shaft wall or enclosure.

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 1306.10. Branch taps that are extended beyond shafts or enclosures, 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 Overload 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 1306.10.

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 1306.10, 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 enclosure, 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 enclosed 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 enclosures, and the like, together with cabinets and metallic raceways supplied from such systems, shall be grounded in accordance with Section 130.9. 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.

Appendix I. Extracts from Building Code

PART V—FACTORIES, OFFICE AND MERCANTILE BUILDINGS

SECTION 5—LIGHTING.

Order 5410. All passageways and stairways when used at night shall have lights at the head and foot of each flight of stairs, and at the intersections of all corridors and passageways. Where "B" fire escapes are required, such fire escapes shall be lighted whenever the stairways are required to be lighted. For red exit lights see Order 5132.

All gas jets or gas lights in factories or workshops where combustible material is used, shall be properly enclosed by globes or wire cages, or otherwise properly guarded. See also Orders 5224, 5225.

Note: For further requirements on lighting see Industrial Lighting Code for Factories, Mills, Offices, and other Work Places issued by the Industrial Commission.

SECTION 8—FIRE ALARM.

Order 5413. An approved fire alarm system shall be provided in every factory or workshop where more than 10 persons are employed above the second story, except buildings which are provided with a complete automatic sprinkler system, and except fireproof buildings whose contents are practically incombustible.

PART VI—THEATERS AND ASSEMBLY HALLS.

SECTION 1—CLASSIFICATION.

Order 5500. Theaters. This classification includes all buildings or parts of buildings used for theatrical, operatic, or motion picture performances of a public nature, except as provided in the following order.

Order 5501. Assembly Halls. This classification includes all buildings or parts of buildings not included under "theaters," where 100 or more persons assemble for entertainment, instruction, worship or dining purposes.

A private assembly hall is one built in connection with a school, club, church, or society building, and used only for

private gatherings, and not rented for public use. Every other assembly hall is a public assembly hall.

Occasional private motion picture performances may be given in a private assembly hall, but in all such cases a fireproof booth must be provided according to Orders 5538–5546.

Occasional private theatrical or operatic performances may be given in a private assembly hall; but in all such cases the stage must be protected as in Orders 5519–26, 5533–34.

Occasional motion picture or theatrical performances (not over twice a week) may be given in a public assembly hall which is located on the first floor, accommodates not over 300 persons, and is situated in a community of not over 500 population having no regular theater; in all such cases a fireproof booth must be provided and the stage must be protected as in Orders 5519–5526, 5533, 5534, 5538–5546. No place of assemblage shall be located over any such assembly hall.

SECTION 10—STAGE.

Order 5524. Footlight Trough. The footlight trough shall be made of incombustible material.

SECTION 14—LIGHTS.

Order 5529. Oil and Gas. (See also Order 5224.) No oil lamp shall be used in or about any stage containing scenery.

No gas lighting of any kind shall be used on any stage containing scenery, nor in any property room, storage room, scene dock, or fly gallery, except in localities where electricity is not available. Gas fire used for heating water, etc., shall be enclosed in iron jackets.

Note: For theaters where outside electric current is not available, a private electric plant is strongly recommended.

Order 5530. Exit Lights: Theaters. Exit lights shall be provided over all exits (both usual and emergency) and in such other places as may be necessary to direct the audience, performers, and employes to a street or alley. Such exit lights shall be either

(1) Electric lights. (See Order 5225, and special requirements for theaters in the Wisconsin State Electrical Code.)

(2) Candles, or oil lamps using non-volatile oil and floating wick; such lights shall be properly shielded from drafts and from adjacent woodwork or other combustible material.

Note: If such candles or oil lights are used, the management must, of course, be particularly careful to see that the lights are properly maintained and lighted before every performance.

Every light over an exit (both usual and emergency) shall be provided with a red illuminated sign bearing the words "exit" or "out" in plain letters at least 5 inches high, or a similar sign shall be placed below a red light.

All public parts of the theater (except the auditorium), and all exit lights, shall remain lighted throughout every performance and until the audience has left the building.

Order 5531. Exit Lights: Assembly Halls. Every assembly hall in which the auditorium is not kept lighted throughout every performance or entertainment, shall be lighted the same as required for theaters. (Order 5530.)

In all other assembly halls, all stairways, passageways, and exit doors shall be properly lighted and shall remain lighted throughout every performance or entertainment and until the audience has left the building. Emergency exit doors shall be marked with red lights as in Order 5132.

SECTION 16—FIRE PROTECTION.

Order 5536. Fire Alarm. Every theater which accommodates more than 1,000 persons shall have a fire alarm box on the stage.

SECTION 18—MOTION PICTURE MACHINES AND BOOTHS.

Order 5543. Electric Wiring. All exposed electric wiring in the booth shall have an approved slow burning insulation. Each lamp connected with a picture machine shall be provided with a separate switch located within the booth.

PART VII—SCHOOL BUILDINGS, LIBRARIES AND MUSEUMS

SECTION 12—LIGHTING.

Order 5620. Artificial Lighting. Each classroom of standard size (32 feet long by 23 feet wide) shall be equipped with at least six artificial lighting units symmetrically spaced.

Where electric service is available at least one circuit of 15 amperes capacity (see Wisconsin State Electrical Code) shall be supplied to each standard classroom.

See Orders 2181 to 2189, inclusive, of the School Lighting Code issued by the Industrial Commission.

SECTION 14—FIRE ALARMS.

Order 5622. Every building two stories or more in height shall be provided with a proper alarm or gongs which can be operated from any story, including basement, and can be heard throughout the building. Such alarm system shall be tested at least once a week.

PART VIII—APARTMENT HOUSES, HOTELS AND PLACES OF DETENTION

SECTION 6—LIGHTS.

Order 5715. In every building which accommodates more than 4 families or 30 persons, and in every building which accommodates transients, the public passageways and stairways and exit doors shall be illuminated from one hour after sunset to one hour before sunrise. This illumination shall include lights at all intersections of passageways, at all exits, and at the head and foot of every stairway. The lights at emergency exit doors shall be red lights and shall be accompanied by a sign bearing the words "exit" or "out," in plain letters.

See also Orders 5224, 5225, and 5132.

SECTION 16—FIRE ALARM.

Order 5727. In every building which accommodates 20 or more transients, there shall be a proper alarm or gongs which can be operated from any story and can be heard throughout the building. Every such alarm system shall be tested at least once every week.

Appendix J. Dry Cleaning Establishments

(h) No gas or gasoline engine, steam generator or heating device and no electric dynamo or motor or other electrical machine, apparatus or device shall be located, maintained or operated inside of any room used for the business of cleaning and dyeing, except electric motors, machines, apparatus or devices, which are free from all explosion, fire and spark hazards, and which are approved for such use by the industrial commission. (Chapter 67, Laws of 1929)

(i) The lighting of such cleaning and dyeing rooms shall be secured only by keyless socket, incandescent electric lights with globes or bulbs in vapor proof receptacles. All

switches, cut-offs or fuses used in the installation and operation of such lights shall be located and operated from the outside of such cleaning and dyeing rooms. All interior electrical equipment must conform with the most advanced approved standards of the art at the time of installation.

Appendix K. Extracts From Industrial Lighting Code

Order 2113. Shading of Lamps for Overhead Lighting.

Lamps suspended at elevations above eye level less than one-quarter their distance from any position at which work is performed, shall be shaded in such a manner that the intensity of the brightest square inch of visible light source does not exceed seventy-five candle-power.

Exception: Lamps suspended at greater elevations than twenty feet above the floor, are not subject to this requirement.

Note: Glare from lamps or unduly bright surfaces produces eye strain and increases the accident hazard.

The brightness limit specified in this order is an absolute maximum. Very much lower brightness limits are necessary in many interiors illuminated by overhead lamps, if the illumination is to be satisfactory. In some cases, the maximum brightness should not exceed that of the sky (1.5 to 3.0 candle-power per square inch).

Where the principal work is done on polished surfaces, such as polished metal, celluloid, varnished wood, etc., it is desirable (but not mandatory at present) to limit the brightness of the lamps in all downward directions to the amount specified in this order.

Order 2114. Shading of Lamps for Local Lighting.

Lamps for local lighting shall be shaded in such manner, that the intensity of the brightest square inch presented to view from any position at which work is performed, does not exceed three candle-power.

Note: In the case of lamps used for local lighting, at or near eye level, the limits of permissible brightness are much lower than for lamps used for overhead lighting, because the eyes are more sensitive to strong light received from below, and because such light sources are more constantly in the field of view.

Order 2116. Emergency Lighting.

Emergency lamps shall be provided in all work space aisles, stairways, passageways, exits, and on all "B" fire escapes (three feet and four inches wide—See Building Code), to provide for reliable operation when, through accident or other cause, the regular lighting is extinguished. Emergency lighting systems, including all supply and

branch lines, shall be entirely independent of the regular lighting system and shall be concurrently in operation with the regular lighting.

Note: It is the intention of this order to guard against accident due to the failure of the regular lighting system, by providing sufficient illumination to enable the occupants to

1. Avoid contact with moving machinery and other danger points until the regular lighting is again put in operation.
2. To vacate the building safely and expeditiously when this is necessary because of fire or other causes.

Emergency lighting may be installed in various ways. The method to be employed depends upon the size of the premises, the extent of the hazards of employment, and the means available for supplying such emergency lighting.

Order 2117. Switching and Controlling Apparatus.

Switching or controlling apparatus shall be so placed that at least pilot or night lights, which may be part of the emergency lighting system, may be turned on at one or more easily accessible points. All such apparatus shall be plainly labeled for identification.

Note: The purpose of this order is to make it possible for the night watchman or other qualified persons to turn on enough lamps, when entering any portion of the premises at night, to enable them to safely see their way around without the need of a lantern or flashlight.

Appendix L. Extracts From School Lighting Code

Order 2187. Exit and Emergency Lighting.

In school buildings of more than one story hereafter constructed, the lighting to be provided in all stairways and exits and in the passageways appurtenant thereto under Order 2183 shall be connected independently of the room lighting. Such lighting (and "exit lights"—see Building Code) shall be so supplied as not to be subject to failure because of the failure of the room lighting from internal causes.

Note: Electric emergency lighting should be supplied from an independent connection extending back to the main service entrance for the building.

Order 2188. Switching and Controlling Apparatus.

At each point of entrance to school buildings hereafter constructed, switching or controlling apparatus shall be installed, so that a person may turn on enough lamps of the

emergency lighting to proceed safely to the next point of control.

Note: It is recommended that in the case of classrooms and large assembly rooms, auditoriums, etc., switching or controlling apparatus for turning on a portion of the lamps of the room be located at each point of entrance to such room.

Appendix M. Extracts From General Orders on Existing Buildings

Order 6037.

All new electrical work shall conform to the Wisconsin State Electrical Code, comprising General Orders 1000–1499, inclusive, of the Industrial Commission.

All electric wiring and installations which by reason of insufficient supports, defective insulation, contact with combustible materials, or with conductors of electricity, deterioration, faulty materials or from any other cause, is liable to cause fire shall forthwith be overhauled, repaired or replaced, and made safe, and all such repair work shall be done as required by said Wisconsin State Electrical Code.

Decorations of paper, cotton, cloth or other combustible materials shall not be attached to electric light wires, globes or fixtures, nor within three feet of any open lights.

Electric cords shall not be hung on or be fastened with or come in contact with nails, staples, hooks, gas or water pipes, machinery or other metal supports.

Pendant lamps must be free from contact with furniture, machinery, posts or other fixtures.

Where portable electric lights must be used the same shall be equipped with keyless socket of non-combustible, non-absorbent insulating material, large handle of non-absorbent insulating material, basket guard, proper reflector and special heavy duty cord of the reinforced or similar type.

Appendix N. Extracts From General Orders on Safety in Construction

Order 3519. Illumination.

Adequate illumination shall be provided at the head and foot of all stairs and ladders which are open to use and at openings in floors. (See also Industrial Lighting Code issued by the Industrial Commission.)

Appendix O. Extracts From General Orders on Spray Coating

Order 2062—Equipment.

(1) **Electrical Equipment.** Electrical equipment other than approved lamps and motors approved for use in explosive atmospheres shall not be installed in spray booths. All lamps installed in spray booths shall be enclosed in vapor-proof globes, except where ceramics only are applied. Lamps shall not be installed inside the spray booth or room unless approved in writing by the Industrial Commission, except where ceramics only are applied.

Note: As the walls are required to be smooth, this will require openings for illumination to be carefully fitted with wired glass, with lamps on the outside.

All electrical equipment exposed to flammable spray vapor or residue shall be installed, operated and maintained in accordance with all the requirements of the Wisconsin State Electrical Code applying to such locations.

All wiring in booths or exposed to flammable spray vapor or residue shall be placed in rigid metal conduit.

Gas filled or mercury vapor lamps, in incombustible dustproof enclosures ventilated to the outside air, may be installed as an integral part of a spray booth when separated from the interior of the booth by tight-fitting wired glass panels arranged to admit the light into the booth.

(2) **Grounding.** All exposed noncurrent carrying metal parts of electrical equipment serving such booths, and all metal parts of the booth themselves, unless only ceramics are applied, shall be bonded together and permanently and effectively grounded in accordance with the provisions of the Wisconsin State Electrical Code. (See Section 103.) All belts driving in or entering contaminated airways from booths shall, unless ceramics only are applied, be similarly grounded to prevent accumulation of static charges of electricity.

Precaution. A very frequent cause of fire in a spraying room is the spark produced by the friction of steel on steel (or iron), or a flinty material on steel as obtains in the scraping and rubbing processes. Scrapers and rubbers should be of nonferrous and nonflinty material where possible. Users should thoroughly acquaint themselves with the spark-producing hazards of solids and fluids.

(3) **Illumination.** All booths shall be provided with illumination of an intensity of at least five-foot candles measured on a horizontal plane thirty inches above the floor. The distribution of illumination shall be reasonably uniform, avoiding objectionable shadows and sharp contrasts of brightness. To minimize glare, lamps shall be shaded in accordance with Orders 2113 and 2114 of the Industrial Lighting Code.

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 or 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

SECTION 150. SCOPE

Order 1500. Scope.

The orders of part 5 apply to radio transmitting and receiving installations, including antennas, counterpoise wires, lead-in conductors, grounding conductors, grounding connections, protective devices, and batteries. The orders do not apply to antennas used for coupling carrier-current equipment to line conductors.

In case the installation is covered by more than one order, the superior requirement shall apply.

SECTION 151. CLASSIFICATION OF RADIO STATIONS

Order 1510. Classification of Radio Stations.

For the purpose of these orders radio stations are classified as follows:

A. Receiving Stations.

B. Transmitting Stations.

1. Low Power.—Transmitting stations to which the power supplied is less than 100 watts and where the voltage of the power supplied is less than 400 volts.

2. Medium power.—Transmitting stations not classified as low power or high power.

3. High power.—Transmitting stations to which the power supplied is greater than 1,000 watts or where the voltage of the power supplied is greater than 2,000 volts.

SECTION 152. ANTENNA AND COUNTERPOISE INSTALLATION

Order 1520. Application of Orders.

These orders apply to the following:

A. Outdoor antennas of all classes of receiving and transmitting stations. (There are no requirements for indoor antennas.)

B. Counterpoise wires.

Order 1521. General Requirements.

A. Counterpoise wires. Counterpoise wires shall conform to the requirements for antennas similarly located.

B. Antennas of receiving and low-power transmitting stations. Such antennas shall, in general, comply with the requirements for the construction of communication lines for public use in similar situations.

C. Antennas of medium and high power transmitting stations. Such antennas shall, in general comply with the requirements for the construction of supply lines in similar situations.

Order 1522. Locations to be Avoided.

The following situations should be avoided in erecting antennas and guy wires:

A. Attachments to supply or communication poles.

B. Crossings over railroad tracks or public highways.

C. Crossings over supply or communication conductors.

D. Crossings under supply or communication conductors.

E. Antenna conflicts with supply or communication conductors. (See definition of "Antenna conflict".)

Order 1523. Ordinary Construction of Antennas.

Antennas shall be constructed according to the requirements of order 1523 when they do not cross over railroad tracks, supply conductors, or communication conductors and do not conflict with supply or communication conductors.

A. Antenna conductors.

1. Material.

(a) Receiving Antennas.

No requirements.

(b) Transmitting Antennas.

Antennas shall be of copper, bronze, copper-covered steel, or other metal which will not corrode excessively under the prevailing conditions.

2. Size. Antenna conductor sizes shall be not less than given in Table 1.

TABLE 1.—ANTENNA CONDUCTOR SIZES—ORDINARY CONSTRUCTION

Material	Receiving Antennas		Transmitting Antennas			
			Low power		Medium and high power	
	Size A. W. G.	Diameter	Size A. W. G.	Diameter	Size A. W. G.	Diameter
		Inch		Inch		Inch
Copper.						
Soft-drawn	14	0.064	14	0.064	7	0.144
Medium-drawn	14	.064	14	.064	8	.128
Hard-drawn	14	.064	14	.064	10	.102
Bronze or copper-covered steel	17	.045	14	.064	12	.081

3. Strength.

(a) ANTENNAS OF RECEIVING AND LOW-POWER TRANSMITTING STATIONS.

No requirements.

(b) ANTENNAS OF MEDIUM AND HIGH POWER TRANSMITTING STATIONS.

The strength of the antenna conductor shall be not less than that of No. 10 A. W. G. (diameter 0.102 inch) hard-drawn copper.

B. Antenna insulators.

1. Antennas of receiving and low-power transmitting stations. No requirements.

2. Antennas of medium and high power transmitting stations. Insulators shall be of noncombustible material and shall have a creepage distance of not less than 10 inches.

C. Antenna supports.

1. Strength of supports. Supports shall be of such initial size as to carry the vertical load and where necessary shall be guyed or braced so as to withstand the transverse and longitudinal loads to which they may be subjected.

2. Roof supports. Antenna supports erected on roofs shall be of rigid construction, and where necessary shall be arranged to distribute the load over the roof. Such supports shall be erected so that they are not dependent in any way on the antenna for stability.

3. Chimneys. The attachment of antennas to chimneys should be avoided.

4. Grounding metal supports on roofs. Metal poles or masts extending more than 10 feet above the supporting building shall be permanently and effectively grounded.

5. Trees. Where a tree is used as an antenna support, sufficient sag (or other means) shall be provided to keep

the tension in the antenna safely below the breaking strength when the tree sways in the wind.

D. Attaching antennas to supports.

1. Strength of attachment. The means used for attaching the antenna to the support shall be such as to withstand a greater load than that which will break the conductor itself.

2. Attachment on small poles. If the pole is not strong enough to support a person, some arrangement shall be provided to draw up the antenna from the ground.

E. Minimum clearance above ground.

1. Spans 150 feet or less in length. Antenna conductors shall have clearances above ground as given in Table 2.

TABLE 2.—MINIMUM ANTENNA CLEARANCE ABOVE GROUND

Location	Receiving and low power antennas	Medium and high power antennas
	Feet	Feet
Above streets and other traveled roadways	18	28
Along road in rural districts	15	28
Above roadways to residence garages	10	
Above spaces or ways accessible only to pedestrians	10	

2. Spans exceeding 150 feet in length. For such spans the above clearances shall be increased by 0.1 foot for each 10 feet in excess of 150 feet.

F. Minimum clearances below supply and communication conductors. Antennas shall have the following clearances from conductors under which they cross:

TABLE 3.—MINIMUM ANTENNA CLEARANCES BELOW OTHER CONDUCTORS

Crossing under—	Receiving and low-power antennas	Medium and high power antennas
	Feet	Feet
Communication conductors	2	10
Supply conductors, 0 to 750 volts	4	10
Supply conductors exceeding 750 volts	6	10

G. Clearances from combustible material. Antennas of medium and high power transmitting stations shall be placed so that an air gap of at least 10 inches exists between the antenna and the nearest combustible material.

Order 1524. Special Construction of Antennas.

Antennas shall be specially constructed according to the following requirements when they cross over railroad tracks, supply conductors, or communication conductors, or are in conflict with supply or communication conductors.

A. Recommendation against locating antennas in situations where special construction is required. It is strongly recommended that the installation of antennas in these special situations be avoided. If such locations are employed, it must be recognized that special hazards are introduced and that great care is necessary in the construction and maintenance of antennas to avoid contact with supply or communication conductors or to avoid the reduction of clearance over railroad tracks.

B. Construction of antennas crossing over or conflicting with service loops 0 to 150 volts to ground. Antennas constructed in these situations shall conform to the requirements for the ordinary construction of antennas (order 1523) and, in addition, with the requirements set forth below for splices (order 1524, C, 2) and for minimum clearances above communication and supply line conductors (order 1524, C–4).

C. Construction of antennas crossing over or conflicting with communication conductors or supply conductors 0 to 750 volts.

1. Antenna conductor strength. The strength of the antenna conductor shall be not less than that of hard-drawn copper of the following sizes:

Span length	Size of hard-drawn copper	
	Size A. W. G.	Diameter
		Inch
0 to 150 feet	8	0.128
Exceeding 150 feet	6	.162

2. Splices. Splices in antenna spans shall be made with a suitable twisted-sleeve connector which will provide a strong unsoldered joint or shall be soldered.

3. Antenna supports.

(a) MATERIAL.

The poles for supporting antennas shall be of steel, concrete, or wood. Wood poles shall be free from observable defects that would decrease their strength or durability.

(b) SIZE.

Wood poles shall have a top diameter of not less than 6 inches.

(c) SETTING.

Poles shall be set to such a depth and in such a manner that any applied load will break the pole before the butt is pulled loose from its setting.

4. Minimum clearances above communication and supply conductors, 0 to 750 volts. Antennas crossing over such conductors shall have the following clearances:

	Feet
Antennas of medium and high-power transmitting stations	6
Antennas of medium and high-power transmitting stations	10

D. Antennas crossing over railroads or crossing over or conflicting with supply lines exceeding 750 volts.

1. Antennas of receiving and low-power transmitting stations. Such antennas shall conform to the requirements for communication lines for public use in similar situations as far as grades of construction and clearances from all other wires and from ground are concerned. (See part 2.)

2. Antennas of medium and high power transmitting stations. Such antennas shall conform to the requirements for supply lines in similar situations as far as grades of construction and clearances from all other wires and from ground are concerned. (See part 2.)

Order 1525. Guarding of Antennas.

Antennas for transmitting stations shall be installed or protected so as to be inaccessible to unauthorized persons.

SECTION 153. LEAD-IN CONDUCTORS

Order 1530. Application of Orders.

The requirements of this section apply to lead-in conductors of receiving stations and transmitting stations of low and medium power. Lead-in conductors of high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

Order 1531. Material.

Lead-in conductors shall be of copper, bronze, copper-covered steel or other metal which will not corrode excessively under the prevailing conditions.

Order 1532. Size.

A. Receiving stations. For receiving stations the size of lead-in conductor shall be not less than No. 14 A. W. G. (0.064 inch) if of copper, or less than No. 17 A. W. G. (0.045 inch) if of bronze or copper-covered steel.

B. Low and medium power transmitting stations. For such transmitting stations the lead-in conductor shall be not less than No. 14 A. W. G. (0.064 inch.)

Order 1533. Installation of Lead-in Conductor.

A. From antenna to first building attachment. This section of the lead-in wire shall conform to the requirements for antennas similarly located.

B. From first building attachment to building entrance. This section of the lead-in conductor shall be installed and maintained so that it can not swing closer to open supply conductors than the following distances:

	Feet
Supply lines 0 to 750 volts	2
Supply lines exceeding 750 volts	10

Exception: The 2-foot clearance may be reduced if the lead-in conductor is separated from supply conductors by a continuous and firmly fixed nonconductor which will maintain permanent separation. This nonconductor shall be in addition to any insulating covering on the wires.

C. From building entrance to set.

1. Receiving stations.

(a) Lead-in conductors shall be securely fastened in a workmanlike manner.

(b) Clearance between lead-in conductor and any supply conductor not in conduit shall be not less than 2 inches.

Exception: This 2-inch clearance does not apply if a firmly fixed nonconductor such as porcelain tube affords a permanent separation. This nonconductor shall be in addition to any insulating covering on the wires.

(c) The lead-in conductor from the building entrance to the set shall have rubber insulation approved for voltages 0–600 (Type R).

2. Low and medium power transmitting stations.

(a) Lead-in conductors shall be securely fastened to suitable insulators.

(b) Clearance between lead-in conductor and any supply wire shall be at least 5 inches.

(c) Lead-in conductors shall be installed and protected to prevent persons from readily coming into accidental contact with them.

SECTION 154. CONSTRUCTION AT BUILDING ENTRANCE

Order 1540. Application of Orders.

The requirements of this section apply to construction at receiving stations and transmitting stations of low and medium power. Construction at building entrances at high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

Order 1541. Entrance Bushing.

Lead-in conductors shall enter the building through a rigid, noncombustible, nonabsorptive, insulating tube or bushing, or through a drilled windowpane.

Order 1542. Creepage and Air-Gap Distance.

The entrance bushing or windowpane mentioned in order 1541 above shall afford the following creepage and air-gap distance from extraneous bodies:

Receiving stations	No requirement
Low and medium power transmitting stations using damped waves	5 inches
Low and medium power transmitting stations using undamped waves	3 inches

Order 1543. Mechanical Protection of Bushings.

Entrance bushings of porcelain or other fragile material at transmitting stations shall be protected where exposed to mechanical injury.

SECTION 155. PROTECTIVE AND OPERATING GROUNDING CONDUCTORS

Order 1550. Application of Rules.

The requirements of this section apply to grounding conductors of receiving stations and transmitting stations of low and medium power. Grounding conductors of high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

Order 1551. General.

The protective grounding conductor may be used also as the operating grounding conductor.

Order 1552. Material and Size.

A. Receiving stations.

1. Material. No requirements.

2. Size.

(a) OPERATING GROUNDING CONDUCTOR.

No requirements.

(b) PROTECTIVE GROUNDING CONDUCTOR.

This conductor shall not be smaller than the lead-in conductor.

B. Transmitting stations. The operating and grounding conductors shall have strength and conductance per unit length not less than No. 14 A. W. G. (0.064 inch) hard-drawn copper.

2. The operating grounding conductor shall be of copper strip not less than $\frac{3}{8}$ 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 $\frac{3}{4}$ inch, such as a No. 2 wire, and shall be firmly secured in place throughout its length.

Order 1553. Installation of Grounding Conductors.

A. Method of running.

1. Grounding conductors shall be run in as straight a line as possible from the set or the protective device to a good permanent ground.

2. Grounding conductors may be run either inside or outside of the building.

Recommendation: It is recommended that the protective grounding wire for low and medium power transmitting stations be run outside of the building.

B. Mechanical protection. Grounding conductors shall be guarded where exposed to mechanical injury.

C. Insulation. Grounding conductors may be of insulated or bare wire and need not be run on insulating supports.

SECTION 156. GROUND CONNECTIONS

Order 1560. Application of Orders.

The requirements of this section apply to ground connections for all classes of transmitting stations and to protective ground connections of receiving stations.

Order 1561. General.

Grounding shall be done in accordance with the following methods. (See section 130.9 for complete orders for grounding)

Order 1562. Gas Pipe and other Ground Electrodes Not to be Used.

A. Gas pipe shall not be used for grounding purposes.

B. Lightning rod, lightning arrester, secondary distribution and telephone ground electrodes shall not be used for grounding purposes.

Order 1563. Water-pipe Grounds.

The ground connections shall be made to a cold-waterpipe where such pipe is available and is in service and connected to the street mains. An outlet pipe from a water tank fed by 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.

Order 1564. Attachment to Pipes.

Grounding conductors shall be attached to pipes by means of suitable ground clamps. The entire surface of the pipe to be covered by the clamp shall be thoroughly cleaned.

Order 1565. Driven or Buried Grounds.

If cold-water pipes are not available, ground connections may be made to a galvanized-iron pipe or to a rod driven into permanently damp earth or to a metal plate or other body of metal buried similarly.

Order 1566. Attachment to Ground Rod or Plate.

The grounding conductor shall be attached to the rod, buried plate, or other body of metal so as to give reliable connection both mechanically and electrically. This connection shall be made so that it will not fail through corrosion, even when the joint is buried in the earth.

An approved ground clamp shall be used where the protective grounding conductor is connected to pipes or piping.

SECTION 157. PROTECTIVE DEVICES

Order 1570. Application of Orders.

The requirements of this section apply to protective devices for receiving stations and transmitting stations of low and medium power. Protective devices for high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

Order 1571. Lightning Arrester.

A. Where required. Each lead-in conductor of a receiving station shall be provided with a lightning arrester, whether or not an antenna grounding switch is used.

Note: If fuses are used, they shall not be placed in the circuit from the antenna through the protective device to ground.

B. Operating voltage. The lightning arrester shall be such as to operate at a potential of 500 volts or less.

C. Location. The arrester may be located outside the building as near as practicable to the point of entrance, or inside the building between the point of entrance and the receiving set and convenient to a ground. The arrester shall not be placed in the immediate vicinity of easily ignitable material or in a location exposed to dust, flammable gases, or flyings of combustible materials.

Order 1572. Antenna Grounding Switch.

A. Where required. An antenna grounding switch shall be used at low and medium power transmitting stations. An antenna grounding switch is not required at receiving stations, but may be used in addition to the lightning arrester.

B. Type of switch.

1. Receiving stations. The switch should be of the single-pole double-throw type.

2. Low and medium power transmitting stations. The switch shall be of the double-throw type and shall meet the following requirements:

Minimum break distance ---------- 4 inches
Minimum cross-section of switch blade ⅛ inch x ½ inch

Switch base: Nonabsorptive insulating material.

C. Location. The switch may be located either outside or inside the building. The switch should be placed in the most direct line between the lead-in conductor and the point where the grounding connection is made.

D. Clearance for live switch parts. The switch shall be mounted so that its current-carrying parts will clear the building wall or conductors not connected to the switch by the following distances:

Switches for receiving stations: No clearance required.

Switches for low and medium power transmitting stations:

Damped-wave sets ---------- 5 inches
Undamped-wave sets ---------- 3 inches

E. Method of connection.

1. Receiving stations. The switch shall be wired so that the antenna lead-in conductor can be disconnected from the set and connected to the grounding conductor. When in the grouding position the switch shall short-circuit the lightning arrester.

2. Low and medium power transmitting stations. No requirements.

F. Operation of switch.

1. Receiving stations. No requirements.

2. Low and medium power transmitting stations. Antenna and counterpoise lead-in conductors of low and medium power transmitting stations shall be connected to the grounding conductor whenever the station is not in use.

Order 1573. Protection Against Kick-back.

A. Where required. Protection should be provided at low and medium power transmitting stations where necessary to protect the supply system against high-potential surges and "kick-backs."

Any of the following methods may be used:

1. Two condensers, usually of 0.1 to 0.5 microfarad capacity and capable of withstanding five times the normal voltage to which they are subjected, placed in series with one another across the supply line with mid-point between condensers grounded. Across (in parallel with) each of these condensers shall be connected a shunting fixed spark gap capable of not more than one thirty-second inch separation.

2. Two vacuum-tube-type protectors in series with one another across the line with the mid-point grounded (if the line voltage does not exceed 110 volts).

3. Electrolytic lightning arresters, such as the aluminum-cell type.

C. Location. Apparatus for protection against "kick-back" should be installed across the supply conductors as near as possible to each radio transformer, rotary spark gap, motor, and generator (in motor-generator sets), or other auxiliary apparatus.

SECTION 158. CONNECTION TO POWER SUPPLY LINES

Order 1580. Connection to Power Supply Lines.

A. Devices used in connection with power supply lines and methods of wiring shall be in accordance with the orders covering permanent or portable fixtures, devices, and appliances. (See Part 3).

B. Radio receiving sets 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.

SECTION 159. BATTERIES

Order 1590. Application of Rules.

The requirements of this section apply to batteries for receiving stations and transmitting stations of low and medium power. Battery installations for high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

Order 1591. Care in Handling.

Care shall be used in handling batteries in order to avoid contacts with terminals having a high enough difference of potential to cause shock.

Order 1592. Storage Battery.

A. Wiring. The wiring of storage batteries used with radio receiving equipment shall be subject to the rules covering the wiring of permanent or portable fixtures, devices, and appliances. (See Part 3).

2. 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 1 ampere in the negative lead. Fuses or circuit-breakers shall be located not more than 18 inches along the wire from a battery terminal.

B. Ventilation. Storage batteries shall be located where there is adequate ventilation.

C. Precautions.

1. Open flames shall be kept away from storage batteries.

2. Storage batteries should be placed on trays or mats of lead, rubber, or other material which will not be affected by the electrolyte.

D. Large battery installations. Installations of non-portable storage batteries of more than 50-kilowatt-hour capacity at the 8-hour rate of discharge, if used for radio, shall comply with sections 113 and 131.8.

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 Gage (0.056 inch) and the diameter of any wire of a cable before galvanizing shall be not less than No. 14 Steel Wire Gage (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 $\frac{5}{8}$ 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 sections connection shall be made to at least four of the sections.

Down conductors shall be connected to the edges of roofs, or to the lower edges of metal siding, by soldered or bolted joints having an area of contact of at least three square inches. If the metal is in small sections, connection shall be made to at least four of the sections.

Order 1615. Number of Down Conductors.

A. *Minimum.* There shall be not less than two down conductors on any type of buildings, and these shall be run so as to be as widely separated as practicable. The following rules shall apply as to additional down conductors.

B. *Rectangular Structures.* On rectangular structures having gable, hip, or gambrel roofs, and exceeding 110 feet in length, there shall be at least one additional down conductor for each additional 50 feet of length, or fraction thereof.

On rectangular structures having French, flat, or sawtooth roofs, and exceeding three hundred feet in perimeter, there shall be at least one additional down conductor for each additional 100 feet of perimeter or fraction thereof.

C. *Irregular-shaped Structures.* On an ell or T-shaped structure there shall be at least one additional down conductor; on an H-shaped structure at least two additional down conductors; and on a wing-built structure at least one additional down conductor for each wing.

On irregular-shaped structures the total number of down conductors shall in every case be sufficient to make the average distance between them along the perimeter not greater than 100 feet.

D. *Structures Exceeding 60 feet in height.* On structures exceeding 60 feet in height there shall be at least one additional down conductor for each additional 60 feet of height, or fraction thereof, except that the application of this rule shall not cause down conductors to be placed about the perimeter of a structure at intervals of less than 50 feet.

E. *Metal-Roofed and Metal-Clad Buildings.* The number of down conductors and ground connections for metal-roofed and metal-clad buildings shall be determined in the same manner as for buildings composed of non-conducting materials, i. e. according to the requirements of A, B, C, and D above.

F. *Dead Ends.* Additional down conductors shall be installed where necessary to avoid "dead ends," or branch conductors ending at air terminals, which exceed 16 feet in length, except that single down conductors descending flagpoles, spires, and similar structures which are adjuncts of buildings shall not be regarded as "dead ends" but shall be treated as air terminals.

Order 1616. Interconnection of Metallic Masses.

A. *Exterior Bodies of Metal.* Metal situated wholly on the exterior of buildings such as ornamental ridges, ventilators, roofs, valleys, gutters, down spouts, structural iron, etc., shall be connected to the conductor at its upper or nearest end, and if of considerable length, shall be grounded

or electrically connected to the conductor at its lower or farthest end.

B. *Interior Bodies of Metal.* Metal situated wholly in the interior of buildings 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 per-

manently 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 comparable to the height of the structure, connection shall be made at the upper and lower extremities; otherwise connection may be made at the nearest point.

E. *Grounding of Metallic Spires and 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 nonconducting material the following rules shall apply.

A. *Iron Posts.* Ground connections may be made by inserting at intervals galvanized-iron posts, such as are ordinarily used for farm fencing, and attaching in electrical contact all of the wires of the fence. If the ground is normally dry the intervals between metal posts shall not exceed 150 feet. If the ground is normally damp they may be placed 300 feet apart.

B. *Iron Pipe.* A less expensive ground connection than A. may be made by driving a length of one-half or three-quarter inch internal diameter galvanized iron pipe beside the fence and attaching the wires by ties of galvanized iron wire. The spacing shall be the same as for the posts under A. above.

C. *Depth of Grounds.* Pipes or posts shall be extended into the ground at least three feet.

Order 1651. Breaking Continuity of Fence.

In addition to grounding the fence its electrical continuity shall be broken by inserting insulating material in breaks in the wires at intervals of about 1000 feet. These insertions may be in the form of fence panels of wood or lengths of insulating material to the ends of which the wires can be attached. Such lengths of insulating material may consist of strips of wood 2 x 2 x 24 inches, or their equivalent as far as insulating properties and mechanical strength are concerned.

Order 1652. Trees.

Where a tree is isolated and the vicinity is much frequented by livestock, the danger from lightning can be reduced by installing a single conductor extending from the top of the tree, to a distance of at least six feet into the ground.

Note: For protection of 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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