Wisconsin State Electrical Code

INDUSTRIAL COMMISSION OF WISCONSIN

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Wisconsin State Electrical Code

Requirements for all electrical and signal equipment of places of employment, public buildings, private buildings, and overhead and underground electrical supply and signal lines, now or hereafter installed.

WISCONSIN STATE ELECTRICAL CODE

Errata

Page 175

Appendix K—Extracts from General Orders on Existing Buildings.
should be
Appendix K—Extracts from General Orders on Spray Coating.

Page 214

Order 1351-d-1. Change second sentence to read:
An individual switch shall be installed in each branch circuit of capacity larger than 15 amperes.

Page 272

Appendix K—Change title to read:
Extracts from General Orders on Spray Coating.

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 Section 1797*m*—102*o* 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 1499, inclusive, effective August 27, 1924;

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 in the future and described as follows:

Electric supply lines, of a voltage of nominally 2300 volts or over between a phase wire and ground or between phase wires.

Electric supply lines, the voltage of which is raised, and when this increase in voltage requires a change in the separation of the wires and clearance, between wires and ground or rails at railroad crossings.

Signal lines, where the construction will produce conflicts (not crossings) between these lines and supply line already constructed.

Exceptions

Lines which are a part of a distribution system within the corporate limits of a city or village, or in communities with similar density of population, are exempted from this order. (See, Note, below.)

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, 1922.

Dated at Madison, Wisconsin, this 12th day of September, 1924.

RAILROAD COMMISSION OF WISCONSIN.

LEWIS E. GETTLE, *Chairman*
ADOLPH KANNEBERG
A. R. MCDONALD
Commissioners

NOTE.—To facilitate the filing of the above information, blank forms will be furnished by the Commission in duplicate upon application. These blanks are to be filled out and sent to the Commission. One of these forms will be returned for filing by the utility if the construction is satisfactory; if not, both will be returned, and violations of the code pointed out; when amended, specifications are to be filed.

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.

By 1919 it had become apparent that revisions in the Electrical Safety Code were necessary, and at the same time the decision had been reached, that since safety and fire prevention are inextricably interwoven, the safety and fire prevention requirements should be combined in a single Electrical Code. With this end in view, the various organizations which it was thought would be interested in assisting in formulating such a code were requested to name representatives to serve on an Advisory Committee. In this way the following committee was named:

C. B. Hayden, Madison, Chairman of Committee, Railroad Commission of Wisconsin.
John A. Hoeveler, Madison, Secretary of Committee, Industrial Commission of Wisconsin.
Dr. M. G. Lloyd, Washington, D. C., U. S. Bureau of Standards.
Thomas Broughton, Madison, Wisconsin Compensation Rating and Inspection Bureau.
George E. Cooper, West Allis, Wisconsin Manufacturers' Association.
Joseph Koetting, Wisconsin Federation of Labor.
A. J. Goedjen, Milwaukee, Wisconsin Utilities Association.
Paul C. Burrill, Milwaukee, State Association of Electrical Contractors and Dealers.
Frank R. Daniel, Milwaukee, Wisconsin Inspection Bureau.
F. H. Runkel, Portage, State Telephone Association.
W. D. Hobbins, Milwaukee, Wisconsin Telephone Company.
T. E. Barnum, Milwaukee, Electrical Utilization Equipment Manufacturers.
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.

As in the case of the Electrical Safety Code adopted in 1917, the Industrial Commission acted jointly with the Railroad Commission, which by Section 1797*m*—102*o* of the statutes is empowered to make and enforce rules and standards to safeguard the public and to prevent service interference in electrical construction and operations. This action was taken to avoid duplication by the two Commissions.

This committee began its work in December, 1919, and periodically held meetings during the remainder of that year and the following years of 1920 and 1921. To assist the committee in its work, a number of technical experts were called upon to consult with the committee in connection with various portions of the code. The persons consulted were as follows:

G. C. Neff, Madison, Wisconsin Power, Light & Heat Company.
G. F. Crowell, Milwaukee, Wisconsin Telephone Company.
C. T. Reiss, Chicago, Western Union Telegraph Company.
A. M. Perry, Chicago, Western Editor, Electrical World.
G. G. Post, Milwaukee, Milwaukee Electric Railway & Light Co.

In January, 1922, the committee presented a draft of the proposed Wisconsin State Electrical Code to the two commissions, and on March 1st and 2nd public hearings were held in the State Capitol at Madison on the code by the two commissions jointly. A number of suggestions for modifying these orders were made at these hearings; all of the suggestions were given full consideration and thoroughly discussed by the Advisory Committee, subsequent to the hearings. Most of these suggestions were considered as very good by the committee and were approved.

A final meeting of the Advisory Committee was held May 2nd, at which the proposed Electrical Code, modified in accordance with various suggestions received at the public hearings, was unanimously approved by the committee and recommended for adoption to the two commissions.

The code as presented by the Advisory Committee is based upon the two excellent national codes, i. e., National Electrical Code of the National Board of Fire Underwriters and the National Electrical Safety Code of the U. S. Bureau of Standards. Valuable suggestions were also obtained from the Electrical Code of the city of Chicago.

On June 5, 1922, the Industrial Commission, pursuant to Sections 101.1 to 101.31 inclusive of the statutes, repealed the

Electrical Safety Code issued and effective since July 1, 1917, and comprising general orders 1000 to 1390 inclusive. On the same day the commission adopted the General Orders, published hereinafter (1000 to 1499 inclusive) and collectively known as the Wisconsin State Electrical Code, pursuant to the same section of the statutes. On August 14, 1922, these general orders were published in the official state paper and became effective on September 13, 1922.

By September, 1923, the first edition of the Wisconsin State Electrical Code had become exhausted. Experience in enforcement had brought to light vagueness in some of the orders, inconsistencies in others and some matters of importance were not covered at all. Moreover, some meritorious new equipment had been developed in the meantime which would be barred by the code as then in effect. Study of the utility of this new equipment showed that an actual gain in safety might be secured with its use and at the same time electrical installations cheapened.

Hence the Advisory Committee was again called together to consider the matter of revising the code before the publishing of the second edition. The changes proposed by the Advisory Committee as a result of its deliberations, were published in pamphlet form and a public hearing was held in the City Hall at Milwaukee on April 16, 1924, at which all interested persons were given the opportunity to present suggestions and criticisms not only of the Committee recommendations but also any other portions of the code. All suggestions and criticisms elicited at the public hearing were referred to the Advisory Committee for further study. This Committee on *May 2, 1924,* made a unanimous report to the two commissions and the second edition of the code has been modified in accordance with these recommendations.

On July 14, 1924, the Industrial Commission, pursuant to Sections 101.01 to 101.31, inclusive, of the statutes, repealed Orders 1020—3, 1031—b, 1034—a, 1035—a, 1036—a, 1101, 1121, 1142—b, 1142—c, 1217—e, 1218—c, 1220—a, 1228—c, 1228—d, 1228—f, 1295—a, 1295—c, 1295—d, 1295—e, 1295—f, 1295—h, 1295—j, 1296—a, 1297—a, 1297—b, 1297—c, 1297—d, 1299, 1301, 1310—a, 1310—b, 1312, 1313—b, 1313—c, 1314, 1320, 1321—b, 1324, 1330—d, 1331—a, 1331—b, 1340—a, 1341—a, 1341—f, 1343—h, 1343—k, 1346—b, 1346—c, 1346—d, 1346—f, 1346—k, 1350—a, 1350—b, 1350—d, 1350—f, 1350—k, 1351—a, 1351—d, 1351—f, 1351—g, 1352—b, 1353, 1354—b, 1355—d, 1356—a, 1357—g, 1357—h, 1358—b-1, 1360, 1361, 1362, 1378—c, 1378—e, 1378—f, 1378—g, 1382, 1391—b, 1391—c, 1391—i. On the same date and pursuant to the same sections of the statutes, the Industrial Commission adopted the following general orders to take the place of those repealed:

1020—3, 1031—b, 1034—a, 1035—a, 1036—a, 1101, 1121, 1142—b, 1142—c, 1217—e, 1218—c, 1220—a, 1228—c, 1228—d, 1228—f, 1295—a, 1295—c, 1295—d, 1295—e, 1295—f, 1295—h, 1295—j, 1296—a, 1297—a, 1297—b, 1297—c, 1297—d, 1299, 1301, 1310—a, 1310—b, 1312, 1313—b, 1313—c, 1314, 1320, 1321—b, 1324, 1330—d, 1331—a, 1331—b, 1334, 1340—a, 1341—a, 1341—f, 1343—h, 1343—k, 1346—b, 1346—c, 1346—d, 1346—f, 1346—k, 1346—m, 1350—a, 1350—b, 1350—d, 1350—f, 1350—k, 1351—a, 1351—d, 1351—f, 1351—g, 1352—b, 1353, 1354—b, 1355—d, 1356—a, 1357—g, 1357—h, 1358—b-1, 1360, 1361, 1362, 1378—c, 1378—e, 1378—f, 1382, 1384, 1391—b, 1391—c, 1391—i. The official publication of this action of the Industrial Commission took place in the official state paper on July 28, 1924, and hence became effective thirty days later, namely August 27, 1924.

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.

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 Part 3, the requirements for utilization equipment, which includes interior wiring and the installation of all current-consuming devices, such as lamps, motors and heating appliances.

WISCONSIN STATE ELECTRICAL CODE

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INTRODUCTORY PART

General Requirements, Definitions, Grounding Methods.

Order 1000. Scope of Code.

This code shall apply as a minimum safety and fire prevention requirement for all electrical and signal equipment of places of employment, public buildings, private buildings, and overhead and underground electrical supply and signal lines now or hereafter installed.

Exceptions: 1. Temporary construction may be used for a reasonable length of time if it is under competent supervision while it or adjoining electrical 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.

2. 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 testing done.

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.

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

Note: It will be the policy of the Commission to approve materials, devices and systems which are listed as standard by the underwriters' laboratories. Therefore such listed materials may be used without submitting them to the Commission, unless upon due notice any such materials have been disapproved by the Commission and provided the manner of use does not conflict with 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.

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 1201, 1202, 1203, Section 120, Part 2.)

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

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. *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.

2. *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.

3. *Circuit.*

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

(b) Branch circuit means that portion of a wiring system for utilization equipment extending beyond the final set of fuses

or circuit-breakers protecting it. The term outlet, when used in connection with orders prescribing the protection of branch circuits, means points on such circuits at which current is taken to supply fixtures, lamps, heaters, motors and current consuming devices generally.

4. *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 lines located thereon.

5. *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.

6. *Conduit.* (See also Definition 11.)

(a) For underground work means a single duct or a group of ducts for underground conductors.

(b) For utilization equipment means rigid metal pipe.

(c) 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 by the manufacturer.

7. *Conflicting or in Conflict,* (as applied to a pole line) means that the line is so situated with respect to a second line (except at crossings) that the overturning 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: Provided, however, that lines on opposite sides of a highway, street or alley are not considered as conflicting if separated by a distance not less than 60 per cent of the height of the taller pole line, but in no case less than 20 feet.

8. *Current-Carrying Part* means any part intended to be connected in or to an electric circuit, upon which a voltage is impressed. *Noncurrent-carrying* parts are those not intended to be so connected.

9. *Dead* refers to current-carrying parts which are free from electrical charge (not having a potential difference from that of the earth).

10. *Disconnector* means a switch which is intended to open a circuit only after the load has been thrown off by some other means. (See also Definition 49.)

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

11. *Duct* means (in underground work) a single tubular runway for underground cables. (See also Definition 6.)

12. *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. (For Definition of Utilization Equipment, see 54.)

13. *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 also Definition 47.)

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.

14. *Electrical Supply Station* means any building, room, or separate space within which is located electrical supply equipment and which is accessible as a rule only to properly qualified persons. (See also Definition 39.)

Note: (1) Supply stations accessible as a rule only to properly qualified persons, must comply with Part 1 of this code. (2) Supply stations accessible as a rule to other than properly qualified persons, must comply with Part 3 of this code. (3) This includes generating stations and substations, generator, storage battery, and transformer rooms, and central stations of signaling systems, but excludes manholes and isolated transformer vaults on private premises. (See Definition 52.)

15. *Explosion Proof* (As applied to protective inclosures of electrical equipment installed in locations where the presence of inflammable gas makes the atmosphere explosive in character) means that an inclosure is of such construction that any explosion of gas which may occur in the inclosure is localized and cannot be transmitted to the exterior thereof. (See also Definition 22.)

16. *Exposed* means that an object or device is not suitably guarded or isolated and therefore can be inadvertently touched or approached nearer than a safe distance by any person. (See also Definition 25.)

17. *Grounded* means connected to earth or to some extended conducting body which serves instead of the earth, whether the connection is intentional or accidental. (See also Definition 36.)

18. *Grounded System* means a system having a permanent and effective electrical connection to earth. This ground connection may be at one or more points. (See also Definition 36.)

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.

19. *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 also Definition 23.)

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

21. *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.

22. *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. (See also Definition 15.)

23. *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.

24. *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.)

25. *Isolated* means that an object is not readily accessible to persons unless special means for access are used. (See also Definition 16.)

26. *Isolation by Elevation* means elevated sufficiently so that persons may safely walk underneath. (See also Definition 19.)

27. *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 also Definition 55.)

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

29. *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 also Definition 55.)

30. *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.

31. *Manual* means operated by personal intervention.

32. *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 also Definition 38.)

33. *New Construction* means all new electrical installations and all repairs and renewals which constitute a substantial portion of the installation or any substantial subdivision thereof.

34. *Open Lines* means overhead lines not in conduits and consisting of single conductors or of individual twisted pairs, as opposed to multiple conductor cables.

35. *Panelboard* means a single panel containing busses, fuses, and switches to control lights, fan motors, and similar devices

usually of small individual as well as aggregate capacity, placed in or against a wall or partition and accessible only from the front.

36. *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 17 and 18.

37. *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.

38. *Portable Equipment* 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 also Definition 32.)

39. *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. (See also Definition 14.)

40. *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 (unless specifically forbidden) or insulating material, and the term includes wooden and metal moldings consisting of a backing and capping and also metal ducts into which wires are to be pulled.

41. *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 also Definition 33.)

42. *Rural Districts* means all places not urban, usually in the country, but in some cases within city limits. (See also Definition 53.)

43. *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.

44. *Sag—Apparent sag at any point* means the 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.

45. *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, at 60° F., with no wind loading.

46. *Service* means the connecting conductors by which a supply of electrical energy is carried from a supply line to main switch and fuses or circuit-breakers within the building or premises served.

Note: This service is ordinarily divided into two parts, one extending from the supply lines to the building line and the other from the building line to the main switch and fuses or circuit-breakers.

47. *Signal Lines* means lines for public or private signal or communication service and devoted exclusively to the transmission of signals or intelligence, 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. Below 150 volts no limit is placed on the capacity of the system. (See also Definition 13.)

Note: 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. Signal lines not for public use coming under the above definition may be constructed and operated as supply lines, if desired, and if consistently so constructed and operated.

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

49. *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. (See also Definition 31.)

50. *Switchboard* means a large single panel or assembly of panels on which are mounted (partly on the face and partly on the back) switches, fuses, busses and usually instruments, and which are accessible both in front and in rear. Circuits and machinery of relatively large capacity are controlled from such boards.

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

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

Note: Such isolated fire-proof inclosures should have not less than a six-inch noncombustible sill at doorway and floor should be drained to some convenient point outside building in which vault is installed.

53. *Urban Districts* means thickly settled communities (whether in cities or suburbs) where congested traffic often occurs. A highway even though in the country, on which traffic is often very heavy, is considered as urban. (See also Definition 42.)

54. *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 signal lines. (For Definition of Supply Equipment, see 12.)

55. *Vertical Conductor* means, in pole wiring work, a wire or cable extending in an approximately vertical direction. (See also Definitions 27 and 29.)

56. *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, low-voltage circuits, *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.

57. *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 these rules.

SECTION 103. METHODS OF PROTECTIVE GROUNDING.

Order 1030. General.

The following orders of this section apply to the grounding of all lightning arresters, circuits, equipment and conduit, when the grounding is required as a permanent and effective protective measure by this code.

Exception: The following orders do not apply to the grounding of arresters on signal circuits and radio equipment, to the grounded return of trolley or third-rail systems, nor to the grounding of lightning protection wires where these are not connected to electrical circuits or equipment.

Note: The orders requiring grounding, in accordance with the methods specified below, are included under Parts 1, 2, 3 and 4 of this code.

Order 1031. Points of Attachment of Ground 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 but not at individual services or within buildings served.

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

(b) *Alternating-current Distribution Systems.*

(1) In alternating-current distribution systems the ground connection shall be made at the building service or near the transformer (or transformers) either by direct ground connection through water-piping system or artificial ground (see order 1033) or by the use of a system ground wire to which are connected the ground conductors of many secondary mains, and which is itself effectually grounded at intervals that will fulfill 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-phase conductor or on the neutral point of one phase.

Note: The ground connection should be made to that point of the system which will enable making connection to water pipe, rather than artificial grounds.

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

(7) 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.

(8) 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.

(9) Alternating-current secondary circuits shall not be grounded inside buildings, 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 Ground Conductor.*

Grounds shall be so arranged that under normal conditions of service there will be no objectionable flow of current over the ground conductor.

Note: Where the use of multiple grounds results in objectionable flow of current over the ground conductors, one or more such multiple grounds should be abandoned or the location changed.

(d) *Lightning Arresters and Ground Detectors.*

For lightning arresters and ground detectors the ground connection shall be at such a point that the ground conductor is as short and straight as practicable.

(e) *Equipment and Conduit.*

(1) For conduit, frames of generators, motors and transformers, and other noncurrent-carrying metal parts of electrical equipment, the point at which the ground conductor is attached shall be accessible.

(2) For conduit the ground 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.

Note: To insure electrical continuity of a conduit system, it is necessary to securely fasten all conduit in outlet boxes, junction boxes and cabinets, and to remove non-conducting protective coatings, such as enamel, from threads on conduit and couplings and from surface where approved ground clamp is fastened to conduit.

Order 1032. Ground Conductor.

(a) *Material and Continuity.*

(1) In all cases the ground conductor shall be of copper or other metal which will not corrode excessively, and if practicable, shall be without joint or splice. If joints are unavoidable they shall be so made and maintained as to conform to the resistance and current-carrying capacity requirements of Order 1035.

(2) In no case shall an automatic cut-out be inserted in the ground conductor or connection, except in a ground connection from equipment where its operation will result in the automatic disconnection from all sources of energy of the circuit leads connected to equipment so grounded. (See also Order 1031—b-6 and 1351—a-2.)

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

(b) *Size and Capacity.*

(1) The ground conductor or conductors for grounding circuits shall have a combined current-carrying capacity sufficient to insure the continuity and continued effectiveness of the ground connection under conditions of excess current, caused by accidental grounding of any normally ungrounded conductor of the circuit. No individual ground conductor for electrical circuits shall have less current-carrying capacity than that of a Number 6 A. W. G. copper wire, except that for additional grounds after the first ground on any circuit, smaller ground wires may be used, provided they have a conductance equivalent to No. 10 A. W. G. copper wire.

(2) The ground conductors for a three-wire direct-current system shall have a combined current-carrying capacity not

smaller than the neutral conductor to which they are attached except that the capacity need not be larger than the largest feeder of the same system leaving the station.

(3) The ground conductors for alternating-current systems shall have a combined current-carrying capacity not less than one-fifth that of the conductor to which they are attached, except that they need not have a conductance greater than that of No. 0 A. W. G. copper wire.

(4) For lightning arresters the ground conductor or conductors shall have a combined current-carrying capacity sufficient to insure continuity and continued effectiveness of the ground connection under conditions of excess current caused by or following discharge of the arrester. No individual ground conductor shall have less conductance than No. 6 A. W. G. copper wire.

(5) For noncurrent-carrying metal parts of electrical equipment, except conduit, armoured cable or metal raceways, the conductance of a ground conductor shall be not less than that provided by a copper wire of the size indicated in the following table:

Capacity of Nearest Automatic Cut-out	Required Size of Ground Conductor—A. W. G.
200 to 500 amperes	4
100 to 200 amperes	6
0 to 100 amperes	10
0 to 10 amperes (for portable equipment only)	18

When current-carrying conductors of portable equipment are larger than No. 18 A. W. G. ground conductor must be of same size.

When there is no cut-out protecting the equipment, the size of ground conductor shall be determined by the design and operating conditions of the circuit.

(6) Ground wires for conduit shall have a conductance at least equivalent to No. 10 A. W. G. copper wire, where largest wire contained is No. 0 A. W. G. copper wire or less. A ground wire of a conductance at least equivalent to No. 4 A. W. G. copper wire shall be used where largest wire contained is larger than No. 0 A. W. G. copper wire.

(c) *Insulation and Guarding.*

(1) All ground conductors of circuits or equipment operating at less than 750 volts shall be adequately insulated for the voltage of the circuits or equipment grounded.

Exception: Substantial bare ground conductors may be used in stations, and bare wires may be used if laid slack underground.

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

(3) Guards for lightning arrester ground conductors shall be non-magnetic material unless the ground conductor is electrically connected to both ends of the guard.

(4) The ground conductor, except in rural districts, shall be guarded by being enclosed in insulating conduit or molding if connected to an artificial ground.

Order 1033. Nature of Ground Connection.

(a) *General.* The ground connection shall be permanent and effective and shall be made as indicated below, but always to water piping systems if they are available.

Note: "Available" in this rule means ordinarily within 500 feet for stations.

(b) *Piping Systems.*

(1) In supply stations, ground connections for circuits, equipment and arresters shall be made to all available active 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 ground connections shall be made to at least one such system.

Note: Ground connections from circuits should not be made to jointed piping within buildings except water piping.

(3) Gas piping systems shall not be used for making ground connections.

Exception: Where connection to another type of ground from an electric or combination lighting fixture would involve a long run, and the fixture therefor is not within reach of plumbing or other grounded surfaces, the gas piping may be utilized as the ground connection, provided it is bonded to the water-piping system at its point of entrance to the building.

(c) *Alternate Methods.* Where suitable underground metallic piping systems are not available, other methods which will secure the desired permanence and conductance shall be employed.

Note: In many cases, metal well casings, local metal drain pipes, and similar buried metal structures of considerable extent will be available, and may be used in lieu of extended buried water-piping systems.

In some cases, ground connections may be made to the steel frame of a building containing the grounded circuits or equipment. In such cases the building frame should be itself well grounded by effective connection to the ground. This may require artificial grounding for steel frame buildings supported on masonry or concrete (unreinforced) footings.

(d) *Artificial Grounds.* When resort must be had to artificial grounds their number 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. At least two grounds are required for low voltage alternating-current distribution circuits at transformers or elsewhere.

Note: It is recommended that one of these grounds be installed at the customer's service.

(2) 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 it is desirable to provide guards for the ground conductor in accordance with Order 1032c wherever it is otherwise accessible, or to provide insulating mats or platform so located that persons cannot readily touch the ground conductor without standing on such mats or platforms.)

(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 concrete flooring, or other flooring reasonably insuring against the disturbance of water pipe, the ground connections may be made on the building side of the meters, if meters are suitable shunted.

(2) When the making of a ground to a piping system outside meter or other device would involve a long run, connection for equipment or conduit (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 ground 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 clamp firmly bolted 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.* Artificial Grounds shall be located below permanent moisture level where ground water level is close to the surface. Where it is impossible to locate the artificial grounds below permanent moisture level, they shall be at least 6 feet below the surface.

Note: Each ground plate should present not less than 2 square feet of surface to the soil, and where facilities are not available for determining the resistance of the ground connection (See Order 1035), the exposed surface should be 4 square feet. Where copper ground plates are used, they should be at least .065 inch thick; and when cast-iron plates are used, they should be at least .25 inch thick.

When driven pipes are used, they should be of galvanized iron and not smaller than one inch internal diameter and extend not less than six feet below the ground.

Order 1035. Ground Resistance.

(a) *Limits.* The combined resistance of the ground wires and connection of any grounded circuit, equipment or lightning arrester shall not exceed the values given below:

Amperes	Water Pipe Grounds Ohms	Artificial Grounds Ohms
Less than 10	15	25
10 to 25	6	25
25 and above	3 or less	25

Exception: Where because of dry or other high-resistance soils it is impracticable with artificial grounds (other than those protecting low-voltage alternating-current distribution circuits) to obtain resistances as low as the values given above, two grounds as defined in Order 1034—c shall be installed, except as in Order 1033—d-2, and no requirements will be made as to resistance.

Note: The current stated opposite the different resistances in the table is either the current-carrying capacity of a circuit from which leakage can occur to the grounded circuit or the continuous current-carrying capacity to which the grounded equipment conduit or lightning arrester is limited by design or by automatic cut-outs.

The product of the corresponding numbers in the first and second columns is never greater than 150—that is, the potential difference due to the stated current is never greater than 150 volts—where connections are made to water pipes.

Where more than one ground is made on the same circuit, equipment, conduit or arrester in the same vicinity, all such grounds are considered collectively in respect to meeting the requirements of this order.

Where a secondary is exposed only through transformer windings, this current-carrying capacity will be that of the primary fuse of the transformer. Where the secondary is exposed to the conductors of conflicting or crossing high-voltage circuits, the current-carrying capacities will be those of the automatic cut-outs in such circuits.

(b) *Checking.*

Note: Ground connections on distribution circuits should be tested for resistance when installation is made unless multiple grounding to water-piping systems is used.

(1) The resistance of station grounds shall be checked when made.

Note: (1) With artificial grounds this check may be made by measuring the voltage between the grounded point of the circuit or the grounded frame of the equipment, or the grounded point of the lightning arrester, and an auxiliary metal reference rod or pipe driven into the ground, while a measured current is flowing through the ground connection and any exposed metal piping or other artificial ground in the vicinity, but not within 20 feet.

(2) If the station ground is to water piping, the check may be made with current flowing through the water piping and some independent piping systems or artificial ground in the vicinity, but not within 20 feet.

(2) All ground connections shall be inspected periodically.

Order 1036. Separate Grounds and Ground Conductors.

(a) *Ground Conductor.* Ground conductors shall be run separately to the ground (or to a sufficiently heavy grounding bus or system ground cable which is well connected to ground at more than one place) from equipment and circuits of each of the following classes:

1. Lightning arresters.
2. Secondaries connected to low voltage lighting or power circuits.
3. Secondaries of current and potential instruments 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, conduit systems, etc., other than covered by Item 4.
6. Lightning rods.

Exception: A common ground conductor for secondary distribution circuits and service conduit at the service entrance will be permitted provided the utility supplying the service has placed on such secondary circuits one or more permanent and effective grounds as required by Order 1313 (b) which meet the resistance requirements of Order 1035.

Note: Lightning-arrester ground connections should be spaced as far as practicable from other artificial grounds. A space of at least 20 feet should be secured where possible.

(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

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PART I

Electrial Supply Stations, Substations and Equipment.

SECTION 110. SCOPE OF ORDERS

Order 1100. Stations and Substations.

The following orders (1100 to 1199 inclusive) apply to all electrical supply equipment of indoor and outdoor stations and substations.

Order 1101. Electrical Supply Equipment in Factories.

Orders 1100 to 1199 inclusive also apply to electrical supply equipment, including generators, motors, storage batteries, transformers and lightning arresters installed in factories, mercantile establishments, or elsewhere, provided the equipment is in separate rooms or similar inclosed areas in charge of a qualified person and accessible only to such persons. (See also Order 1301, Section 130, Part 3.)

SECTION 111. GENERAL PROTECTIVE ARRANGEMENTS OF STATIONS AND SUBSTATIONS

Order 1110. General Requirements for Rooms and Spaces.

(a) *Not to be used for Storage of Materials.* Rooms and spaces in which electrical supply equipment is installed shall not be used for the storage of material nor for manufacturing processes.

Exception: Materials or processes incidental to the production or distribution of a supply of electrical energy are exempted.

(b) *To be Dry and Free from Flyings and Inflammable Gases.* Such rooms and spaces shall be free from flyings and inflammable gases, and when indoors shall be dry and well ventilated. (See also Order 1144.)

Order 1111. Illumination of Stations and Substations. (See also Order 1144-e.)

(a) *Intensity of Artificial Illumination.* Rooms and spaces in which electrical supply equipment is installed shall be provided with artificial illumination of an intensity at least equal to the minimum foot-candles of the following table:

	Minimum Foot-Candles	Modern Practice Foot-Candles
(1) Switchboard instruments 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 t ‹2

Note: The above illumination values apply to the working surfaces and measurements are to be made on the vertical, horizontal, or intermediate plane, as may be required.

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

(b) *Fixtures and Plug Receptacles.* (See also Order 1346—f, Section 134 of Part 3.)

(1) Lamps and fixtures shall be so located as to be readily accessible for replacement, trimming, cleaning, etc., and shall have their control readily accessible.

(2) Lamps and fixtures shall be so located as to make unnecessary the use of portable cords in dangerous proximity to live electrical equipment.

(c) *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. (See also Order 1144—e.)

(d) *Shading of Lamps.* Overhead and local lamps shall be shaded as required by Orders 2113 and 2114 of the industrial lighting code.

Order 1112. Requirements for Buildings and 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.

(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.

(c) *Exits.* All such rooms shall have proper exits as called for by the Building Code.

(d) *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.

Order 1113. Fire Fighting Appliances.

Each room or space, where an operator is in attendance, shall be provided with fire-extinguishing appliances of a type which may be safely used on live parts.

Note: Fire extinguishers employing carbon tetra-chloride as the extinguishing agent are recommended.

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

SECTION 112. PROTECTIVE ARRANGEMENTS OF ELECTRICAL SUPPLY EQUIPMENT

Order 1120. Guarding Live Parts.

(a) *Equipment.*

(1) All ungrounded current-carrying parts of equipment shall be suitably guarded if elevated less than the following distances above floors or platforms:

Voltage of Part	Elevation in Feet
300 to 750	7.0
750 to 2,500	7.5
2,500 to 7,500	8.0
7,500 to 30,000	9.0
30,000 to 70,000	10.0
70,000 to 100,000	12.0
Over 100,000	14.0

Exception: Where no guards are called for elsewhere in these orders, uninsulated current-carrying parts operating at less than 7500 volts need not be guarded regardless of elevation, if the following conditions are complied with:

(1) Insulating mats or platforms are to be provided.

(2) If there are such live parts operating at 300 to 750 volts on one side of the space, there shall be a minimum clearance of 2.5 feet; if on two sides, 3 feet.

(3) If there are such live parts operating at more than 750 volts on one side of the space, there shall be a minimum clearance of 3 feet; if on two sides, 5 feet.

(2) Where guards must at times be opened, thereby exposing live parts, they shall be of insulating material or so arranged that they cannot readily make contact with live parts while being removed.

(3) Where persons must at times enter inclosures, while such parts are alive, the guards shall be of insulating material, or insulated from ground, unless removed horizontally 3 feet, for voltages up to 750, and 5 feet or more, for higher voltages.

(4) All such live parts of equipment of outdoor stations and in stations located in tunnels or subways, shall be inclosed in weatherproof cases.

Exception: Equipment designed to withstand the prevailing atmospheric conditions and which has the live parts suitably guarded against contact or isolated by elevation is exempted.

(b) *Generators, Motors, Motor-generators and Converters.* (See also Order 1150.)

(1) Insulated steps or platform with insulated handrails, if necessary, shall be provided on or about large machines, operating at voltages which will admit of adjustment of live parts, to afford ready access to these parts.

(2) With machines having exposed live parts above 300 volts to ground insulating mats or platforms shall be so placed that operators cannot readily touch live parts unless standing on the insulating mats or platforms.

(3) Machines having exposed live parts above 750 volts to ground, shall have suitable inclosing or barrier guards in addition to the mats or platforms called for in (2) above.

(c) *Storage Batteries.* (See also Order 1144.)

The arrangement of cells and connections shall be such that no two current-carrying parts between which a voltage exceeding 150 volts exists, shall be closer than 3 feet.

Exception: If the parts are not so exposed that persons are liable to make accidental contact with both at the same time, a lesser spacing is permissible.

(d) *Switches, Fuses, Circuit-Breakers.* (See also Orders 1140 and 1141.)

(1) All switches interrupting circuits over 750 volts shall be of the remote control type or shall be enclosed in casings which permit of operation without opening the inclosure, thereby protecting the operator at all times against danger.

Note: Large-capacity, high-voltage oil switches should be placed away from the operator and operated by remote (or level) control, since the blowing up of the oil containers may cause serious injuries to persons in the vicinity. It is recommended that they be inclosed in separate fireproof cells or compartments. (See also Order 1141—c-2.)

(2) All switches interrupting circuits below 750 volts shall be provided with insulating handles and suitable insulating guard disks or shields so arranged between the handles and the live parts as to prevent the hand from slipping into contact with live parts or being burned by arcing at the switches.

Exception: Switches interrupting circuits below 300 volts are exempted from this order.

Note: For the purpose of this order voltages in excess of 750 will be included as below 750 where the excess is for purpose of regulation only.

(3) All fuses and circuit-breakers on circuits over 750 volts which are not isolated by elevation in accordance with a-1 above, shall have all current-carrying parts inclosed.

(4) Where live parts of switches, operating at more than 300 volts to ground, are not remotely controlled or inclosed, as permitted in (2) above, insulating floors, mats, or platforms shall be so placed that the operator must stand on them while operating the switches or adjusting fuses and circuit-breakers.

(5) When switches, disconnectors and fuses above 750 volts which are ordinarily guarded or isolated by elevation as required by a-1 above must occasionally be operated without such protection, adequate working space shall be provided so that the operator will not be required to bring any part of his body within the following distances of the part:

Voltage of Part	Distance in Feet
750 to 7,500	1
7,500 to 30,000	2
30,000 to 50,000	3
50,000 to 70,000	4
70,000 to 100,000	5
Above 100,000	6

Note: Below 7500 volts the distance above specified may be reduced if the operator uses suitable operating devices.

(e) *Switchboards.* (See also Order 1142.)

(1) All switchboards located near passageways shall be guarded from these by suitable inclosures or barriers, and shall be made inaccessible to other than authorized persons. Spaces

at rear of switchboards, which might be used as passageways, shall be inclosed by screens or barriers at ends of board.

(2) Insulating floors, mats or platforms shall be so placed at front and rear of boards, having exposed live parts operating at more than 300 volts to ground, that the operator must stand on them while operating or working at the switchboard apparatus.

(3) There shall be no exposed ungrounded current-carrying parts on the face of any switchboard, operating at voltages over 750 volts, at an elevation less than 7.5 feet above floor or platform.

Exception: (1) Direct-current railway boards up to 1500 volts, so constructed that the operator cannot inadvertently come in contact with parts having a difference of potential over 300 volts, are exempted from this order.

Note: Dead face panels and remote control are recommended where isolation by elevation is undesirable or impracticable.

(4) Exposed ungrounded current-carrying parts over 750 volts on back of switchboards, when not isolated by elevation in accordance with a-1 above, or when working spaces called for in exceptions to a-1 above are not possible, shall be guarded. Parts above 7500 volts shall be isolated as required by a-1 above or shall be guarded.

(5) Plug-type switchboards shall have no exposed current-carrying parts on the face of board in excess of 150 volts to ground, except at times of making or breaking connections.

(f) *Lightning Arresters.*

(1) Current-carrying parts of lightning arresters shall be isolated as required by a-1 above or guarded.

(2) Lightning arresters on circuits of 7500 volts or more shall be provided with disconnectors. (See also Order 1143—c.)

(g) *Conductors.* (See also Section 113.)

(1) Conductors operating at voltages over 750 volts, when brought closer to the floor line than the distances specified in a-1 above, or where subject to mechanical injury, shall be guarded by permanent screens, by inclosing partitions, barrier, guards or by inclosure in metal conduit, metal ducts, runways or compartments of tile, bitumenized fiber, concrete or other suitable fire-resistive materials.

(2) All conductors shall be adequately insulated for the voltage of the circuit to which they are connected.

Exception: Bus-bars and similar conductors are exempted from this provision, but must be constructed as required by the other provisions of this order.

(3) Where conductors with insulating coverings are closely grouped, as on the rear of switchboards or in cableways, they shall each have a substantial flame proof outer covering.

(4) Large conductors liable to be torn from their supports by the stresses 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, whether insulated or not.

(5) Ungrounded conductors of outdoor stations and sub-stations located in tunnels or subways, when not run in conduit, shall be installed on suitable insulators, and properly guarded or isolated by the elevations of (a-1) above, except metallic sheathed cables having metallic sheath permanently and effectively grounded.

(h) *Separation and Barriers.* All bare parts at different potentials shall be effectively separated, and on circuits of large capacity or operating at 7500 volts or higher, if liable to short-circuiting by tools or other conducting objects, shall be provided with suitable barriers. (See also Order 1142—e.)

Order 1121. Where Explosives and Inflammables Exist. (See also Orders 1144—e and 1144—f.)

Where explosives and inflammables exist in dangerous quantities, the equipment shall be installed as called for in Order 1312, Section 113 of Part 3.

Order 1122. Grounding.

(a) *General.*

Circuits shall be grounded as required by Order 1313, Section 131 of Part 3.

Exception: Station auxiliary alternating-current systems are exempted from this requirement.

(b) *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.

Note: Sometimes this will require marking to distinguish such a low-voltage circuit from others which are protected by a ground.

(c) *Non-current-Carrying Metal Parts.*

Exposed non-current-carrying metal parts of equipment operating at voltages above 100 volts to ground shall be grounded in accordance with the methods set forth in Section 103 of Introductory Part.

Exception: (1) All equipment in locations where there are no exposed grounded surfaces within the reach of persons when touching the parts under consideration and where none of the conditions listed as hazardous in Order 1312 exist, and provided the voltage at which the equipment operates is less than 150 volts to ground, is exempted from this order.

(2) All equipment accessible only to qualified persons, provided it is effectively insulated from ground, provided insulating mats, platforms or floors are present, on which qualified persons may stand, and provided there are no exposed grounded surfaces within reach of said qualified persons, at such times as said qualified persons may be in contact with any live part, is exempted from this order.

(3) 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.

(4) Metal parts, such as name-plates and card-holders on switchboards, not likely to become alive by leakage from live parts, are also exempted from this order.

(5) Metal cases of instruments, which are isolated in accordance with Order 1120-a are exempted from this order.

(6) Exposed non-current-carrying metal parts of supply equipment for signal circuits are exempted from this order, providing they are suitably insulated from the ground and neighboring grounded conductors and surfaces.

(7) Metal shell sockets and metal guards of portable lamps, if suitably insulated, are exempted from this order.

(d) *Lightning Arresters and Ground Detectors.*

Lightning arresters and ground detectors shall be grounded in accordance with the methods set forth in Section 103 of the Introductory Part.

Order 1123. Identification. (See also Order 1142—d-2.)

All electrical supply equipment shall be suitably marked to indicate the voltage, capacity, intended use, and other essentials for safe operation.

Order 1124. Deteriorating Agencies. (See also Order 1144—f.)

Suitable guards 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 other equipment or in locations where dripping oil, excessive moisture, steam, vapors, or similar injurious agents exist.

SECTION 113. INSTALLATION AND PROTECTION OF WIRES. INSTALLATION OF CONDUIT AND OTHER INCLOSURES FOR WIRES. CABINETS AND JUNCTION BOXES

Order 1130. Compliance with Other Orders.

The installation of all conduit, both rigid and flexible, metal surface raceways, armored cables, cabinets and junction boxes, and the installation and protection of wires shall be made to comply with Sections 133 and 134, respectively, of Part 3 and in addition shall comply with the following orders of this section. (See also Order 1120—g and 1150—c.)

Order 1131. Station Wiring Requirements. (See also Order 1142—c-3.)

(a) *Conduits, Ducts and Runways.* The interior of conduits ducts and runways shall be smooth, and all edges at outlets shall be smooth to prevent abrasion of the insulating covering of the wires.

(b) *Open Wiring.* All open wiring shall be exposed to view.

(c) *Lead-sheathing and Flame Proofing Covering Where Conductors Terminate.* Where conductors terminate, lead-sheathing and flame proofing covering, when used on conductors, shall be stripped back on the conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuits on which the conductors are used.

(d) *Potheads on Circuits above 750 Volts.* On systems above 750 volts the insulation of the several conductors, where leaving the metal sheath of cables, shall be thoroughly protected against moisture and mechanical injury by means of potheads or other equivalent means.

(e) *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.

SECTION 114. SWITCHES, DISCONNECTERS, FUSES, CIRCUIT-BREAKERS, SWITCHBOARDS, LIGHTNING ARRESTERS AND STORAGE BATTERIES

Order 1140. Switches and Disconnectors. (See also Order 1120-d.)

(a) *Compliance with Other Orders.* The installation of all switches and disconnectors shall be made to conform to Order 1350, Section 135 of Part 3, except as otherwise provided in this order and Order 1120—d and e.

(b) *Where Switches Are Required.* (See also Order 1120—f-2.) Suitable switches shall be inserted in all leads to generators, motors, transformers and all out-going and incoming supply circuits.

Exception: (1) Grounded conductors and leads to instrument transformers and instruments are exempted from this order.

(2) In cases such as between generators and transformer banks used with the generators, disconnecters only will be required.

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

(4) In underground manholes or in transformer vaults, switches are not required, if not deemed necessary to meet operating requirements.

(5) Automatic circuit-breakers that disconnect all wires of the circuit may serve as switch for motors.

(c) *Switches for Short-Circuiting and Grounding.* Switches or other suitable means shall be provided to facilitate short-circuiting and grounding equipment or lines for which the operating rules (Part 4) require such protection to workmen. (See also Order 1142—f and 1151—b-1.)

(d) *Where Disconnectors Are Required.* Switches, which do not make an air break, on circuits operating at voltages in excess of 750, shall be protected by disconnectors between them and the source of energy supply. (See also Order 1120—f-2.)

Order 1141. Automatic Overload Circuit-Breakers and Fuses. (See also Order 1120—d.)

(a) *Compliance with Other Orders.* The installation of all circuit-breakers and fuses shall be made to conform to Order 1351, Section 135 of Part 3, except as otherwise provided in this order and Order 1120—d and e.

Exception: Open link fuses may be used in stations and substations. (See also Order 1351—b, Section 135, Part 3.)

(b) *To Be Installed in All Leads.* Automatic overload circuit-breakers or fuses shall be installed in all leads where switches are required by Order 1140-a and the appended exceptions. (See also Order 1150—e-1.)

Exception: (1) Switches between alternating-current generator and station bus-bar need not have overload protection.

(2) Series transformers and constant current circuits are exempted from this order.

Note: See Order 1032—a-2, Section 103 of Introductory Part, for requirements of automatic cut-outs in grounded conductors.

(c) *Locations.*

(1) Such automatic overload protective devices shall be installed as near as practicable to the bus-bar.

Exception: Where there are no bus-bars these automatic overload protective devices shall be installed as near as practicable to the point where the conductors enter the station.

(2) On circuits of indoor stations operating at a voltage in excess of 7500 volts, oil circuit-breakers shall, where practicable, be enclosed in separate fireproof cells or compartments, or shall be separated by suitable barriers.

Order 1142. Switchboards. (See also Order 1120—e.)

(a) *Accessibility and Convenient Attendance.*

(1) All switches on switchboards shall be so arranged that the points of control are readily accessible to the operator.

(2) Instruments, relays and other devices requiring reading or adjustment shall be so placed that work can be readily performed from the working space.

(b) *Location.*

(1) Switchboards shall be so placed that the operator will not be endangered by any live or moving parts of machinery or equipment located near the board and so as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

(2) There shall be a space of three feet between top of switchboard and combustible material, unless switchboard is otherwise properly guarded to prevent igniting combustible material.

(3) Switchboards shall be accessible from front and rear when the connections are on the back.

Note: This is also desirable when all connections are in front of board.

(c) *Required Equipment and Construction.*

(1) Switchboards which control outgoing supply circuits shall be equipped with such instruments as are necessary to show operating conditions.

Exception: Switchboards in substations without regular attendance are exempted.

(2) Switchboards shall be made of non-combustible material.

(3) In wiring switchboards, the ground detector, volt-meter, pilot lights and potential transformers shall be connected to a circuit of not less than No. 14 wire that is properly protected by fuses. This circuit shall not carry over 660 watts.

(4) Insulated conductors, where closely grouped as in rear of switchboards, shall each have a substantial flame proof outer covering. Such 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.

(d) *Arrangement and Identification.*

(1) Connections, wiring and equipment of switchboards and panel boards shall be arranged in an orderly manner.

(2) All switches and automatic cut-outs shall be plainly marked, labeled or arranged so as to afford ready means for identifying circuits or equipment supplied through them. (See also Order 1123.)

(e) *Spacings and Barriers Against Short Circuit.* (See also Order 1120—h.)

(1) The number of bare parts on switchboards which are at different potentials shall be as few as possible and shall be effectively separated.

(2) Where the voltage between bare parts exceed 750, suitable non-combustible barriers shall be used between them unless isolated by elevation or so located as not to be liable to be short circuited or grounded by tools or other devices.

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

(f) *Means Required to Readily Make Occasional Grounds.*

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 to be grounded to the ground connection. (See also Order 1140—c.)

(g) *Ground Detectors.* Each ungrounded distribution system in a station under attendance shall be provided with reliable ground detectors.

Note: Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable.

Order 1143. Lightning Arresters. (For Guarding see Order 1120-f, for Grounding see Order 1122 and Section 103 of Introductory Part.)

(a) *Where Lightning Arresters Are Required.* All overhead lines to stations or substations shall be protected by lightning arresters.

(b) *Location.* Lightning arresters, when installed inside of buildings, shall be located as far from all other equipment and combustible parts of the building as practicable.

Note: It is recommended that lightning arresters of the aluminum cell or other types containing oil be installed in individual fireproof cells or compartments.

(c) *Provisions for Disconnecting.*

(1) On circuits over 7500 volts, lightning arresters 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 of not less than four times the equivalent needle point sparking distance of the operating voltage of the circuit to which the arresters are connected and in no case less than eight inches. (See also Order 1120—f-2.)

(2) Such disconnectors shall be remotely controlled and operated or shall have the adjacent working space required by Order 1120—d-5.

(d) *Choke Coils.* All choke coils or other attachments, inherent to the lightning protection 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.

Order 1144. Storage Batteries. (For Guarding see Order 1120—c.)

(a) *Scope of Order.* This order applies only to storage batteries exceeding 50 kilowatt hours capacity at the eight-hour rate of discharge.

(b) *Isolation.* Storage batteries shall be placed in separate rooms or inclosures accessible only to properly qualified persons.

(c) *Ventilation.* (See also Order 1110—b.)

(1) Such rooms or inclosures shall be so ventilated as to remove acid spray and prevent dangerous accumulation of inflammable gas.

(2) Communication of drafts to other rooms shall be prevented.

(d) *Suitable Supports and Floors.*

(1) The cells shall be supported by suitable insulators.

Exception: Small cells of insulating material are exempted.

(2) Suitable drainage or other means shall be provided beneath cells to prevent accumulation of electrolyte in case of leakage or spraying.

Note: Acid-resistive floors, such as vitrified brick set in pitch, are recommended where large batteries are installed.

(e) *Lamps.* (See also Orders 1111 and 1121.)

(1) Lamps inside storage-battery rooms shall be of the electric incandescent type, inclosed in vapor tight globes.

(2) Switches controlling such lamps shall be located outside of the battery room or shall be of the vapor proof type.

(f) *Acid-Resistive Coverings on Conductors.* Conductors in battery rooms, if of such material or so located as to be liable to corrosion, shall have suitable protective coverings or coatings. (See also Orders 1121 and 1124.)

SECTION 115. ROTATING EQUIPMENT, TRANSFORMERS, REACTANCES, INDUCTION REGULATORS, BALANCE COILS AND SIMILAR EQUIPMENT

Order 1150. Rotating Equipment. (See also Order 1120-b.)

(a) *Speed-Limiting Devices.*

(1) Prime movers driving generating equipment shall be protected with automatic speed-limiting devices where harmful overspeed can otherwise occur.

(2) Such devices shall be in addition to their governors, if necessary, as with some types of turbines.

(3) Separately excited direct-current motors, series motors, motor generators and converters shall have protective devices as required by Order 1357—c, Section 135 of Part 3.

(b) *Stopping Devices.* 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.

(c) *Control Circuits to Be in Conduit.* Where speed limiting or stopping devices or remote control switches are electrically operated, the control circuits, by which such devices are actuated, shall be in conduit or otherwise suitably protected from mechanical injury.

(d) *Motors.* All motors shall be installed in the manner required by Order 1357, Section 135 of Part 3.

(e) *Generators.*

(1) Constant potential direct-current generators shall be protected from excessive current by fuses or equivalent device of proper design. (See also Order 1141—b.)

Exception: Public utilities serving lighting systems need not place overload protection between lighting generators and bus-bars where two or more generators operate in parallel or feed into a network supplied from other sources, if reverse current relays are installed.

Note: For two-wire direct-current generators, single pole protection will be considered as satisfying the above order, provided the safety device is so located and connected that the means for opening same is actuated by the entire generator current, and the action thereof will completely open the generator circuit.

(2) For two-wire direct-current generators, used in conjunction with balancer sets to obtain a neutral for three-wire systems, a protective device shall be installed, which in case of excessive unbalancing of voltages will operate to disconnect the balancer set and the connected three-wire system.

(3) For three-wire, direct-current generators, compound or shunt wound, a safety device shall be placed in each armature lead, and also connected as to receive the entire current from the armature. Such safety device shall be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature system.

Exception: If such generators are designed to safely carry on each side of the three-wire system the maximum load that may be placed upon it by the opening of one of the outside lines and the carrying capacity of the neutral wire will not be exceeded by such load the safety device need not be interlocked.

Note: The safety device may consist of either: (1) a double-pole, double coil, overload circuit-breaker, or (2) a four-pole circuit-breaker, connected in the main equalizer leads and tripped by means of two overload devices, one in each armature lead.

Order 1151. Transformers. (For Guarding see Order 1120—a, for Grounding see Order 1122.)

(a) *Location.* (See also Order 1356, Section 135, Part 3.) Transformers shall be so placed that fire and smoke from the burning out of the coils or boiling over of the oil (where oil-filled cases are used) can do no harm.

Note: For oil-cooled transformers used in stepping voltage up or down before distribution, this will usually require a separate fire-proof building, room or compartment cut off from the plant proper, provided with not less than 6-inch non-combustible sill at doorway and with floor drained to some convenient point outside the building. Transformers of the air-cooled type should be isolated from all other equipment, and if of air-blast type should be supplied with air through fire-proof ducts.

(b) *Current Transformer Secondary Circuits.* (See also Order 1140—c.)

(1) Secondary circuits of current transformers, including constant current and instrument transformers, shall be provided with means 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.

Exception: (1) Current transformers supplying relays only, or those having their primary circuits always disconnected before the secondary circuits are worked on, are exempted from this order.

(2) Where primaries are more than 7500 volts, secondary circuits, unless otherwise adequately protected from injury or contact of persons, shall be in permanently grounded conduit.

PART 2

Electrical Supply and Signal Lines

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PART 2

Electrical Supply and Signal Lines

SECTION 120. SCOPE OF ORDERS AND GENERAL REQUIREMENTS

Order 1200. Scope of Orders.

The following Orders 1201 and 1299 inclusive apply to all electrical supply and signal lines in overhead and underground construction.

Note: (1) It is not the intent of these orders to recommend a type of construction and all lines must be so designed as to meet service requirements, the specified standards being regarded as minimum requirements.

(2) Accepted good practice for the given local conditions should be followed in all particulars not specified in these orders.

Order 1201. Design and Construction. (See also Orders 1012 and 1236.)

All electrical lines and equipment shall be of suitable design and construction for the service and conditions under which they are to be operated and all lines and appurtenances thereof shall be constructed and maintained in accordance with good modern practice.

Note: (1) The requirements of these orders as to spacing, clearances, and strength of construction are minimum requirements. More ample spacings and clearances and a greater strength of construction than the specified minimum may be provided if other requirements are not neglected in so doing.

(2) Service requirements frequently call for stronger supports and higher factors of safety than the minimum requirements of these orders.

Order 1202. Lines Temporarily Out of Service.

Lines temporarily out of service shall be inspected and maintained as though in service.

Order 1203. Lines Permanently Abandoned.

If any support, attachment or conductor of an overhead line has been permanently retired from service, the same shall be removed by its owners.

Exception: Overhead service drops may be disconnected from the circuit and allowed to remain in place when service is discontinued if it is undesirable to remove the service drops.

Note: For the purpose of this order a line not in service shall be considered as abandoned unless definite plans are entertained for its future use.

Order 1204. Isolation, Guarding and Marking. (See also Orders 1205—b and 1213—g.)

(a) *Current-Carrying Parts.*

Conductors and other current-carrying parts of electrical supply lines shall be so arranged as to provide adequate clearance from the ground or other spaces generally accessible to the public and to the employes not authorized to approach such parts or shall be provided with guards so as to effectively isolate them from accidental contact by such persons.

(b) *Non-Current-Carrying Parts.*

In urban districts, ungrounded metal sheathed service cables, service conduits, metal fixtures, and similar non-current-carrying parts where liable to become charged to more than 300 volts to ground shall be so isolated or guarded as not to be exposed to accidental contact by unauthorized persons. Metal poles not guarded or isolated shall always be specially grounded where in contact with metal sheathed cable or metal cases of equipment operating at more than 750 volts.

Note: 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.

(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.

Note: The Railroad Commission of Wisconsin has arranged to furnish at cost proper stencils for the marking of poles in compliance with this order.

(d) *Stepped Poles.*

If supply conductors carrying voltages exceeding 300 volts to ground are carried on poles stepped nearer than 6.5 feet from the ground or from other readily accessible space or on closely latticed poles or towers, guards or warning signs shall be used to protect against careless approach to conductors by unauthorized persons.

Exception: (1) On poles carrying signal cable or twisted pairs below supply conductors one wood block may be placed not less than 3.5 feet from the ground or other readily accessible place without the use of guards or warning signs.

(2) Structures on fenced right of way need not comply with the requirements of this order.

Order 1205. Grounding Circuits and Equipment.

(a) *Methods.*

Permanent grounding for lightning arresters, for circuits, for equipment, and for wire runways shall be done according to the requirements of orders of Section 103, and Order 1313, Section 131, Part 3, except for signal circuit arresters, for which see Order 1391—g and h, Section 139, Part 3.

(b) *Conduit, Cable Sheaths, Hangers, Etc.*

In urban districts metal conduits, cable sheaths, frames, cases and hangers of equipment shall be permanently and effectively grounded.

Exceptions: The above requirements need not be met when such equipment is:

(1) Guarded from accidental contact of by unauthorized persons.

(2) Eight feet or more from the ground or grounded surface.

(3) When metal conduit and cable sheaths enclosing signal conductors or supply conductors of not more than 300 volts to ground are not exposed to probable contact with circuits of more than 300 volts to ground. (See also Order 1204—b and Order 1313—c, Section 131, Part 3.)

Note: Metal conduit above ground, where containing extensions from underground metal-sheathed cable, is considered as sufficiently grounded by the sheath, if the sheath itself is in good contact with earth or is connected to a permanent and effective ground. (See Section 103 Introductory Part.) It is recommended that supply cables have the sheath bonded to any conduit extending above the ground surface.

Order 1206. Arrangement of Switches and Identification of Equipment.

(a) *Switches to Be Indicating.*

All switches shall be readily accessible to authorized persons and shall indicate clearly whether open or closed.

(b) *Uniform Position.*

To minimize operating errors the handles or control mechanism for switches throughout any system shall have the same position when open and a uniformly different position when closed.

Exception: When this is impracticable the switches should be so marked as to minimize the liability to mistakes in operation.

(c) *Location of Conductors.*

All conductors and equipment of electrical supply and signal lines shall be arranged to occupy definite positions, as far as practicable, throughout the system or shall be so constructed, located, marked or numbered as to facilitate identification by employes authorized to work thereon.

Note: This order is not intended to prohibit systematic transposition of conductors.

Order 1207. Tree Trimming.

When trees exist near line conductors operating at voltages exceeding 300, they shall be so trimmed 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, or clearance shall be secured by increasing heights of poles or by other means.

Exception: When conductors operate at voltages less than 7500, where trimming is difficult, the conductor may be protected against grounding through the tree and against abrasion by interposing between it and the tree sufficiently non-absorptive and substantial insulating, tubing or strip, or the use of tree wire.

Note: This order should not be construed as granting permission to trim trees without consent of the owner.

SECTION 121. GENERAL REQUIREMENTS FOR POLE LINES

Order 1210. Compliance with Other Orders and Special Precautions.

(a) *Other Orders.*

(1) The orders of this section apply to all pole lines whether or not they are required by Section 123 to have a definite grade of construction. The additional requirements for supply lines in

those situations which are required to have a definite grade of construction, A, B, C, will be found in Sections 125, 126 and 127. Orders 1211, 1212, 1213 and 1217 apply also to signal lines whether or not they are required by Section 123 to have a definite grade of construction.

(2) The clearances and separations of conductors, climbing space, vertical wiring on all poles and clearances from other structures shall comply with the requirements of Section 122.

(b) *Special Precautions.*

Where conductors are attached to structures other than those used solely or principally for supporting lines, all orders shall be complied with in so far as they apply, and such additional precautions as may be deemed necessary shall be taken to avoid injury to such structures or to the persons using them.

Note: The supporting of conductors on trees and roofs should be avoided.

Order 1211. Location of Poles and Towers.

(a) *Clearances from Hydrants.*

Poles, towers and other supporting structures and their guys and braces shall be so located as to provide horizontal clearances from them to the nearest point of hydrants and signal pedestals of not less than 3 feet and to street edge of curb (unless structures are suitably protected from traffic) of not less than 6 inches.

Note: (1) It is recommended that the clearance of poles from hydrants and signal pedestals be not less than 4 feet.

(2) When hydrants are located at street corners, poles should not be set so far from the corner as to make necessary the use of flying taps inaccessible from the poles. (See also Order 1215—a.)

(b) *Guards.*

Where necessary, poles and towers exposed to abrasion or other damage which would materially affect the strength of the support, shall be protected by guards.

(c) *Clearance from Rail.*

Where railway tracks are paralleled by overhead lines, the poles shall, if practicable, be located not less than 12 feet from the nearest track rail, except that at sidings a clearance not less than 7 feet is allowed. At loading sidings sufficient space must be left for a driveway.

Note: 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.

(d) *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 1212. Guys and Anchors.

(a) *When Required.*

When the mechanical loads to be imposed on poles, towers or other supporting structures are greater than can be safely supported by the poles or towers alone, additional strength shall be provided by the use of guys, braces, or other suitable construction.

(b) *Angles and Dead Ends.*

Guys shall be used when necessary to balance conductor stresses, 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 stresses are considerably unbalanced.

(c) *Guys Take Total Load.*

When guys are used with wood or other poles or towers capable of considerable deflection before failure they shall be able to support the entire stress in the direction in which they act, the pole acting simply as a strut. The guy shall be attached to the structure as near as practicable to the center of the conductor load to be sustained.

(d) *Guy Fastenings.*

Guy wires shall be stranded and where attached to anchor rods shall be protected by suitable guy thimbles or equivalent. Cedar and other soft-wood poles to which any guy having a strength of 10,000 pounds or more is attached, shall be protected by the use of suitable guy shims, and in this case guy hooks or other suitable means shall be provided to prevent the guys from slipping along the poles. Guy hooks or equivalent shall also be used wherever the horizontal distance from anchor to pole is less than two-thirds the vertical distance from the ground line to the point of attachment.

(e) *Guy Insulation.*

Guys attached to metal poles or structures shall be insulated from them by suitable blocking, when liable to be subject to electrolysis of the anchors, unless insulators are placed in the guys themselves.

(f) *Anchor Rods.*

Anchor rods shall be so installed as to be in line with the pull of the attached guy when under load, except when installed in rock or concrete.

Order 1213. Insulators or Mechanical Guards for Guy and Span Wires.

(a) *Where Required.*

Each guy wire or guy cable attached to any pole or structure carrying supply conductors of more than 300 volts to ground, and not more than 15,000 volts, or where exposed to such voltage by other lines shall be equipped with one or more effective insulators located not less than 8 feet above the ground, and at such a point that if the guy wire breaks at or below the insulator or a supply conductor falls upon it, the part above the insulator cannot be reached by pedestrians.

Exception: (1) The placing of an insulator in a guy wire or guy cable will not be required where the guy wire or guy cable is electrically connected to grounded steel structures or to a ground connection on wooden poles.

(2) Where guy wires are uniformly permanently grounded (see Section 103 Introductory Part), throughout any system of overhead lines, strain insulators will not be required.

Note: Insulators should, where possible, be placed at least 6 feet from the pole.

(b) *Two Insulators.*

When the guy wire to any pole carrying supply or signal conductors, or both, is carried above or under overhead supply conductors of more than 300 volts to ground, two or more insulators shall, where hazard would otherwise exist, be used so that so far as possible the exposed section of the guy wire shall be between two insulators. Neither insulator shall be within 8 feet from the ground.

(c) *Grounding of Guys.*

The anchored end of the guy wires attached to wood poles carrying lines of more than 15,000 volts shall, except in rural districts, be permanently and effectively grounded (see Section 103, Introductory Part) wherever this part of the guy has a clearance of less than 8 feet to ground.

Exception: If an insulator is used which is permanently effective against the highest voltage which is liable to be impressed upon it, the above requirement as to grounding need not be met.

(d) *Location of Insulators.*

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.

(e) *Strength.*

Guy insulators shall have a mechanical strength at least equal to that of the guys in which they are installed.

(f) *Span Wire Insulators.*

All span wires, including bracket span wires shall have two suitable insulators inserted between each point of support of the span wire and the lamp or trolley contact conductor supported.

Exception: (1) Single insulation is permitted in trolley span wire or bracket when supported on wooden poles supporting only trolley, railway feeders or signal conductors used in the operation of the railway concerned or on wooden poles supporting other conductors when the insulator used is permanently effective against the highest voltage which is liable to be impressed upon it.

(2) This order does not apply to insulated feeder taps, used also as span wires.

(3) If an insulated hanger is used, such insulated hanger may be considered as one of the required insulators.

(g) *Insulators in Suspension Ropes.*

Effective insulators shall be inserted at least 8 feet from the ground or grounded surface in metallic suspension ropes or chains supporting lighting units.

(h) *Mechanical Guards.*

The earth end of all guy wires or cables attached to buried anchors where exposed to traffic shall be provided with a substantial and conspicuous wood or metal guard not less than 8 feet long.

Note: It is recommended that in exposed and poorly lighted locations such guards be painted white or some other conspicuous color.

Order 1214. Transformers, Regulators, Lightning Arresters, Switches and Similar Equipment on Supply Lines.

(a) *Location on Pole.*

Transformers, regulators, lightning arresters, switches and similar equipment when located below conductors or other attachments shall be mounted outside of the climbing space. On buckarm poles the climbing space and the lateral working spaces parallel to either the line arms or the buckarms shall be kept clear, if practicable. (See also Orders 1223 and 1225.)

(b) *Guarding.*

Current-carrying parts of switches, automatic circuit breakers and lightning arresters, if of more than 300 volts and located on the climbing side of the pole, shall be enclosed or suitably guarded if less than 20 inches from the pole center, except when located on or above the top crossarm. The spacing between transformers and similar equipment of supply lines, and signal equipment including conductors shall not be less than is required for the spacing between supply conductors and signal conductors in similar situations . (See Table 8, Order 1223.)

(c) *Working Space.*

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 so arranged 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 clearance from pole surfaces required in Table 5, Order 1221, for conductors of corresponding voltages. (See also Orders 1424, 1425, 1426.)

Order 1215. Branch Connections.

(a) *Accessibility.*

Connections of branches in supply circuits, service loops, and equipment in overhead construction shall be readily accessible to authorized employes. When possible, connections shall be made at poles or other structures. (See also Order 1211—a.)

(b) *Clearances.*

Such connections shall be so supported and spaced 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. (See also Orders 1225 and 1226.)

Order 1216. Lamps. (See also Order 1363, Section 136, Part 3.)

(a) *Location.*

All exposed metal parts of lamps and all such parts of their supports unless effectively insulated from the parts carrying current shall be maintained not less than 20 inches from surfaces of

pole structures if of wood and maintained at a suitable height above roadways and footways.

Exception: Lamps at pole tops may have less clearance than the above.

Note: When lamps are maintained on the side of the pole structure opposite that designated as the climbing side this clearance may be reduced to 5 inches.

(b) *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 safely sustain the lighting unit. The lowering rope or chain, its supports, and fastenings shall be examined periodically. (See also Order 1213—g.)

Order 1217. Poles and Crossarms.

(a) *Poles.*

Poles used for lines for which no designated grade is required shall be of such initial size, and where necessary so guyed or braced as to safely withstand the loads to which they may be subjected, including linemen working on them. (See also Order 1212.)

(b) *Crossarm Bracing.*

Crossarms shall be securely supported, by bracing, if necessary, so as to safely support loads to which they may be subjected in use, including linemen working on them. Any crossarm or buckarm 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) *Location of Crossarms.*

In general, crossarms shall be maintained at right angles to the axis of the poles and to the direction of the attached conductors, and at crossovers shall be attached to that face of the structure away from the crossing, unless special bracing or double crossarms are used. The Wisconsin statutes require double crossarms at all steam railroad crossings.

Note: Double crossarms 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 crossarms might provide sufficient strength. To secure extra strength, double crossarms are frequently used, and crossarm guys are sometimes used.

(d) *Pole Setting.*

Wooden poles set in earth shall be set in a manner which will give the pole sufficient stability to safely carry the loads which may be placed upon them. (See Table 44 in appendix for recommended depths of settings.)

(e) *Pole Identification.*

(1) Each utility owning in whole or in part, poles, towers, or structures for supporting supply or signal conductors shall mark such structures with the initials of its name, abreviation of its name, corporate symbol, or other distinguishing marks, as follows:

(I) In a community where a particular kind of service is supplied by only one utility, structures owned in whole by this utility need not be marked.

(II) In a community where a particular kind of service is supplied by more than one utility at least every fifth structure owned in whole shall be marked by each such utility.

(III) All jointly owned structures shall be marked by all utilities owning an interest.

Exception: The marking of the first, last and each tenth intervening structure of continuous runs of uniformly and jointly owned structures in urban districts and the marking of the first, last and fortieth intervening structure in rural districts will be considered compliance.

(IV) Structures adjacent to a point where the ownership in whole or in part changes shall be marked by the utilities concerned.

(V) Structures at one side of railroad crossing shall be marked.

Note: The marking of the nearest accessible structure within 700 feet of the crossing shall be considered compliance.

(VI) Double structures, such as span poles, supporting wires, "H" fixtures, etc., shall be identified by marking one structure of the pair.

(2) The identification marks shall be made with paint, stamps, metal tags, brands, or other effective means. The marks shall be of such size and so spaced and maintained as to be easily readable from the ground.

(3) The identification mark shall be placed where practicable between five and seven feet from the ground and on the side of the structure facing the ordinary vehicle traffic.

Note: It is recommended that all joint ownership or occupancy of poles be covered by written contracts or agreements between the parties involved.

Order 1218. Conductors.

(a) *Material.*

All supply conductors shall be of copper, aluminum (with or without steel reinforcements), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions. If of iron or steel and not copper-covered, conductors shall be galvanized.

(b) *Minimum Size.*

Supply line conductors in urban districts shall be not smaller than listed in the following table:

TABLE 1.—MINIMUM SIZES OF SUPPLY CONDUCTORS (URBAN DISTRICTS)

Soft Copper	No. 6 A. W. G.
Hard or Medium Drawn Copper	No. 8 A. W. G.
Steel	No. 9 Stl. W. G.

Stranded Aluminum	Spans 150 Feet or Less	Spans Over 150 Feet
Not reinforced	No. 1 A. W. G.	No. 0 A. W. G.
Steel reinforced	No. 6 A. W. G.	No. 4 A. W. G.

Note: It is recommended that except as modified in Table 9, Order 1246, these minimum sizes for copper and steel be not used in spans longer than 150 feet. Lightning protection wires paralleling the line conductors shall be regarded, in respect to size and material requirements, as supply conductors.

(c) *Protective Covering.*

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.

Order 1219. Minimum Sizes and Sags of Service Leads.

(a) *More than 750 Volts.*

Supply service leads of more than 750 volts to ground shall comply, as to sizes and sags, with the requirements for supply line conductors of the same voltage.

(b) *750 Volts or Less.*

(1) Supply service leads of 750 volts or less in spans not exceeding 150 feet shall be not smaller than the sizes listed in the table below. Such leads shall have sags not less than 12 inches for spans 100 feet or less, 18 inches for spans up to 125 feet, and 27 inches for spans up to 150 feet.

TABLE 2—MINIMUM SIZES OF SERVICE LEADS OF NOT MORE THAN 750 VOLTS

Situation	*Span 150 Feet or Less*
Alone Concerned with signal lines Over supply lines of less than 750 volts	No. 10 if soft copper. No. 12 if medium or hard copper. No. 12 if steel.
Over trolley of less than 750 volts Over any trolley in rural districts Over supply lines of 750 to 7500 volts Over supply lines of more than 7500 volts in rural districts	No. 8 if soft copper. No. 10 if medium or hard copper. No. 12 if steel.
Over trolley lines of more than 750 volts in urban districts Over supply lines of more than 7500 volts in urban districts	No. 6 if soft copper. No. 8 if medium or hard copper. No. 9 if steel =Grade C requirements.

(2) Supply service leads of 750 volts or less in spans exceeding 150 feet shall be not smaller than required for Grade C in Table 9, Order 1246, and shall have sags not less than required for Grade C in the sag tables of Appendix A.

(c) *Cabled Service Leads.*

In lieu of separate conductors supply service leads may be grouped together in a cable, no individual conductor of which shall be of less size than permitted for separate conductors. The sags shall be the same as required above, for the individual conductors where carried separately.

SECTION 122. CLEARANCE AND SEPARATION OF WIRES

Order 1220. Clearances of Conductors and Wires at Crossings.

(a) *Heights of Wires.*

The clear space between the lowest overhead line conductor, guy, messenger, arc or trolley span wire or lightning protection wire and the surface of rails, streets, highways, alleys or generally accessible spaces across or above which the former pass, shall not be less than that given in Table 3 at 60° F. with no wind, where the conductor or wire has fixed supports and the span does not exceed 150 feet.

The Wisconsin Statute reads as follows:

"Electric Lines on Highways; Place of Poles; Penalty, Section 1329-a.

"(1) Any person, firm or corporation may, with the written consent of the supervisors of the town, construct and operate a line of telegraph, telephone or electric wires for the purpose of transmitting light or power along or within the limits of any highway, subject to the restrictions and conditions herein contained.

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

"Poles, Crossarms, Wires: Security, Distance, Heights, Section 1778-a—1.

"It shall be unlawful for any person, firm or corporation to string any wire, electric or other, over the tracks of any steam railroad company except in accordance with the provisions of this section. All such wires shall be suspended over a double crossarm attached to a pole at each side of the crossing. The poles shall not be less than six inches in diameter at the top, set not less than five feet in the ground, securely guyed, and, unless the railroad right of way is not of greater width, shall be set not more than one hundred feet apart at such crossings. All such wires shall be tied to insulators on pins set in the crossarms. The crossarms shall be attached to the poles by machine bolts and braced by at least one iron brace from each crossarm to the pole. All such wires shall be maintained not less than twenty-five feet above the surface of the rails at such crossing except the street railway trolley wires shall be maintained not less than twenty-two feet above the surface of the rails at such crossings."

"Railroad Commission to Enforce; Penalties, Section 1778-a—2.

"The Railroad Commission of Wisconsin is hereby vested with authority to enforce the provisions of Sections 1778-a—1 and 1778-a—2 and any person, firm or corporation ordered by the commission to change its wires so as to comply with Section 1778-a—1 and 1778-a—2 failing to comply with such order within ten days from the service thereof shall be liable for a penalty or forfeiture of twenty-five dollars, and to a like penalty or forfeiture for every ten days during which it shall fail to comply with the order of the commission, unless a greater length of time to make such change shall be specified by the commission in said order, or in the manner provided by chapter 142 of the statutes for the collection of forfeitures."

TABLE 3.—CLEARANCES FROM RAILS, STREETS, HIGHWAYS, ETC.

The numbers represent the clearances in feet to be provided by the conductors or wires of classes specified at the heads of columns above places specified at the side of the table.

Nature of Crossing	Signal Conductors, Messengers, Guys, Spans, Lightning Protection Wires, and Supply Lines and Services Less Than 300 Volts to Ground	All Conductors Operating at Voltages from 300 Volts to Ground up to 15,000 Volts Between Conductors	All Conductors Operating at Voltages from 15,000 to 50,000 Volts Between Conductors	Trolley contact Conductors (not feeder cables)
	Feet	Feet	Feet	Feet
Crossing above track rails of steam railroads	(1) 27	(1) 28	30	22
Along streets or alleys in urban districts	(2) 18	20	22	(3) 16
Crossing streets or roads in urban or rural districts	24	24	24	24
Along the roads in rural districts or other places where vehicles are liable to pass	(2) 14	18	20	(3) 16
Crossing above spaces or ways accessible to pedestrians only	(4) 10	15	17	(3) 16

(Reference numbers refer to exceptions and additions below.)

Exceptions and Additions to Table 3.

(1) This clearance may be reduced to 25 feet when paralleled by trolley contact conductor on same street or highway.

(2) This does not apply to guys which are not carried over, but merely beside, streets or alleys unless also over driveways. Over roadways to residence garages 10 feet is sufficient clearance.

(3) This clearance is the minimum clear height in the middle of the trolley contact conductor span and the point of support at the trolley hanger should be at a height not less than 2 feet in addition to this minimum, thus allowing 2 feet for the total maximum sag at 60° F. in span wire and trolley contact conductor.

For trolley contact conductors of more than 750 volts to ground this clearance shall be increased by 2 feet.

(4) For guys 8 feet will be sufficient and no clearance is required for anchor guys not passing across pathways, or for those parallel with sidewalk curbs where traffic guards are provided.

(b) *Increased Clearances.*

(1) For spans exceeding 150 feet clearances shall be increased by 1 inch for each 10 feet of the excess between 150 and 300 feet and by 1 inch for each 20 feet of the excess beyond 300 feet.

(2) For voltages over 50,000 the clearances given shall be increased at the rate of one-half inch for each 1000 volts of the excess.

(3) Where the lowest supply conductor at a crossing over track rails is supported by suspension insulators the initial clearance shall be sufficient to prevent the minimum clearances over rails given in table above from being reduced more than 10 per cent through the breaking of a conductor in either adjoining span.

(4) Provisions for increased clearances are cumulative when more than one applies.

Note: The arrangement of insulators so that they are restrained from displacement toward the crossing will avoid the necessity of any increase over the clearances given.

(c) *Conductors and Wires Crossing Others. Clearances at Wire Crossings.*

The clear space between the lowest overhead line conductor or wire and any other conductor or wire over which the former crosses (except for crossings between conductors and guy wires or span wires on the same poles for which see Table 5, Order 1221) shall not be less than that given in the following table at 60° F. with no wind where the upper conductor or wire has fixed supports and the sum of the distances from the point of intersection to the nearer supporting structure of each span does not exceed 100 feet.

Note: Except in case of trolley contact conductors and associated feeders, lines operating at higher voltages should cross at higher levels.

TABLE 4.—WIRE-CROSSING CLEARANCES IN FEET

Conductors Crossed Over	Conductors Crossing Over					
	Signal conductors	Conductors operating at 0 to 750 Volts	Services operating at Less than 750 Volts	Conductors operating at 750 to 7,500 Volts	Conductors operating at 7,500 to 50,000 Volts	Guys, messengers, span wires, Lightning Protection Wires
Signal including their cables and messengers	2	(2) 4	2	4	6	2
Conductors operating at 0 to 750 volts	* 4	2	2	2	4	2
Conductors operating at 750 to 7,500 volts	* 4	* 2	* 4	2	4	4
Conductors operating at 7,500 to 50,000 volts	* 6	* 4	* 6	* 4	4	6
Trolley contact conductors and associated feeders	(3) 4	(3) (4) 4	4	6	6	4
Guys, messengers, span wires, lightning protection wires and service loops	2	2	2	4	4	(1) 2

Note: (1) Reference numbers refer to exceptions and additions below.

(2) An asterisk before a clearance indicates that lines operating at the voltages stipulated at the top of the column in which the clearance in question appears should not cross over the type of line indicated in the horizontal heading for this clearance.

Exceptions and Additions to Table 4.

(1) Completely insulated sections of guys to supporting structures having no conductors operating at voltages higher than 7500 may have less than this clearance from each other.

(2) A clearance of 2 feet will be permitted where the supply conductor is above the signal 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.

(3) Trolley contact conductors above 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.

(4) Trolley feeders are exempt from this clearance requirement if they are at the same nominal potential and of the same system.

(d) *Increased Clearances.*

(1) Where the sum of the distances from the nearest supporting structures of two spans concerned to their point of crossing exceeds 100 feet the clearances shall be increased by 2 inches for each 10 feet of the excess between 100 and 200 feet and by 2 inches for each 20 feet of the excess beyond 200 feet.

(2) For voltages over 50,000 the clearances shall be increased at the rate of one-half inch for each 1000 volts of the excess.

(3) Where the upper line at a crossing between two lines is supported by suspension insulators, the clearances above lines crossed shall be increased sufficiently above those given in the preceding table to prevent the clearances from being reduced by the breaking of a conductor in either adjoining span by more than 25 per cent below the specified clearance.

(4) The above increases are cumulative when more than one applies.

Note: The arrangement of insulators so that they are restrained from displacement toward the crossing will avoid the necessity of any increase over the clearance given.

Order 1221. Minimum Values of Line Conductor Clearances and Horizontal Separation at the Supports.

(a) *Clearances and Separations.*

At any fixed support the clearances of line conductors from their supporting structures and attachments thereto (except insulators to which any conductor is attached), and the horizontal separation between any two line conductors, shall not be less than the values given in the following table. (The requirements of Order 1222 apply if they give a greater separation than this order.)

Exception: (1) Clearances between individual wires or cables supported by the same messenger or between any group and its supporting messenger are not subject to the provisions of this rule.

(2) The clearances or separations stated may be measured from the center of the supporting insulator instead of from the conductor itself.

(3) Cables, duplex, triplex, and twisted pair conductors, supported on insulators or messengers, whether single or grouped, may be considered single conductors, even though they may contain individual conductors not of the same phase or polarity.

TABLE 5.—MINIMUM LINE CONDUCTOR CLEARANCES AND SEPARATION AT SUPPORTS

Applying to conductors of the same circuit or of different circuits. (See also Order 1223 for lateral working space.)

Classification Concerned	Horizontal Separation between Conductors not of the Same Phase or Polarity	Clearance from Span and Guy Wires Attached to the Same Pole or from Vertical or Lateral Conductors of Other Circuits	Clearance from Surfaces of Poles or Crossarms or from Vertical or Lateral Conductors of the Same Circuit
	Inches	Inches	Inches
Signal	(1) 6	3	(2) 3
Direct current railway feeders No. 4-0 or larger, 0-750 volts	6	(3) 6	3
Railway feeders 750-7,500 volts and direct current railways below No. 4-0, 0-750 volts	(4) 12	(3) (5) 6	3
Supply conductors 0-7,500 volts	(6) (4) 12	(3) (5) 6	3
For all conductors above 7,500 volts add for each kv. over 7,500 volts	0.4	(5) 0.4	0.25

(Reference numbers refer to exceptions and additions below.)

Exceptions and Additions to Table 5.

(1) The preferable minimum separation is 6 inches, but where crossarms having less pin spacing than this have been in regular use a separation of 3 inches will be permitted. This requirement does not apply at points of transposition of signal line conductors.

(2) Signal conductors may be attached to supports on the sides or bottoms of crossarms or on the surfaces of poles if at least 4 feet from any supply line operating at less than 7500 volts and at least 6 feet from any supply line operating at voltages exceeding 7500 volts carried on the same pole or structure.

(3) Where a trolley feeder, supply line or signal line is supported by the span wire concerned this clearance is not required.

(4) Where a separation of 10 inches to 12 inches has already been established by practice for spans having apparent sags of not over 3 feet (See Appendix A for apparent sags in level spans for different grades of construction) and operating at voltages not exceeding 7500 the minimum separation may be continued subject to the provisions of Order 1222.

(5) Clearances from these conductors to guy, span, messenger or lightning protecting wires run in the direction of the line shall not be less than the separation required between two line conductors of the voltage concerned.

(6) Where conductors operating at less than 750 volts all of one material are supported on vertical racks in spans averaging not to exceed 150 feet, the minimum separation of 12 inches may be reduced to one-third of the values given and applied for vertical clearance. (See also Orders 1223—g.)

(b) *Location of Wires.*

Supply lines of any one voltage classification (See Table 8, Order 1223), may be maintained on the same crossarm with the supply lines of the next consecutive classification under any one of the following conditions:

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

(2) If in bridge-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 1225.

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

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

(5) If the two lines concerned are signal lines used in the operation of supply lines and supply lines of less than 7500 volts and are owned by the same utility, provided they are installed as in (1) or (2) above.

Order 1222. Required Line Conductor Clearances and Separations at the Supports.

(a) *Line Conductor Separations According to the Sags.* (See also Table 5, Exception 4.)

(1) The separation at the supports of the conductors of the same or different circuits shall in no case be less than the values given in the following tables at 60° F. with no wind.

(2) The requirements of Table 5 shall apply if they give a greater separation than this.

TABLE 6.—SEPARATION IN INCHES FOR CONDUCTORS SMALLER THAN NO. 2 A. W. G.

Voltage	Separation for Sags Shown						
	36	48	72	96	120	180	240
750	12.0	17.0	24.0	29	34	43	51
2,200	12.5	17.5	24.5	30	35	44	52
6,600	13.5	18.5	25.5	31	36	45	53
22,000	.....	21.5	28.5	34	39	48	55
44,000	.....	.....	33.0	38	43	53	60
66,000	.....	.....	37.0	43	47	57	64

TABLE 7.—SEPARATION IN INCHES FOR LINE CONDUCTORS NO. 2 A. W. G. OR LARGER

Voltage	Sag in Inches						
	36	48	72	96	120	180	240
750	12.0	14.0	17.0	20	22	27	31
2,200	12.5	14.5	17.5	21	23	28	32
6,600	13.5	15.5	18.5	21	24	29	33
22,000	.....	18.5	21.5	24	27	32	36
44,000	.....	.....	.....	29	31	36	40
66,000	.....	.....	.....	.....	36	41	45

Note: The formulas used in the derivation of the above separations are as follows,—for other voltages separation may be calculated by the same formulas.

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

Separation=.2 in. per K. V.$+6\sqrt{{}^{S}/_{3}-8}$.

For conductors No. 2 A. W. G. or larger.

Separation=.2 in. per K. V.$+7\sqrt{{}^{S}/_{12}}$.

S is the apparent sag in inches of the conductor having the greater sag and the resultant separation is in inches. K. V. is the maximum voltage of conductors concerned.

The blank spaces in the table indicate that for these sags and voltages the values obtained by Table 5 are greater than those obtained by the above formula and therefore apply.

(b) *Increased Line Conductor Separations and Clearances at the Supports if Suspension Insulators are used.*

(1) Where suspension insulators are used and are not restrained from movement, the values of conductor separations required by Table 8, Order 1223 or by (a) above shall be increased by one-half the length of the suspension insulator string.

(2) Where suspension insulators are used and are not restrained from movement the conductor clearance from surfaces of supports, from span or guy wires, or from vertical or lateral conductors, shall be such that the value of clearances required by Table 5, Order 1221, will be maintained with an insulator swing of 45° from the vertical position.

Order 1223. Minimum Lateral Working Space and Vertical Separation Between Conductors at Different Levels.

(a) *Height of Working Space.*

The lateral working space between supply conductors and between supply and signal conductors at different levels shall have an approximate vertical height of not less than that given in Table 8 of this order with a minimum of 2 feet.

(b) *Width of Working Space.*

This space on the climbing side of the pole extends laterally from each side of the climbing space to the outer pin position of the arm and with a minimum horizontal width from the face of the crossarm equal to the width of the climbing space required for the highest voltage conductors concerned. (See also Order 1225—a.)

(c) *Freedom from Obstruction.*

No vertical or lateral conductors shall obstruct this working space. Such conductors, if not on the opposite side of the pole from the climbing side, must be at least as far from the crossarm as the width of the climbing space required for the highest voltage conductors concerned.

(d) *Only One Buck Arm.*

Since buck arms obstruct the lateral working space between line conductors not more than one single or double buck arm shall be placed on any pole, unless the voltage of all conductors concerned on the buck arms and adjacent line crossarms above and below

does not exceed 750, or unless the lateral working space required by Table 8 of this order is provided between the conductors attached to the buck arm and the conductors on the adjacent line arms to which the conductors on the buck arm are not connected.

Note: This may be accomplished by increasing the spacing between the line crossarm gains.

(e) *Minimum Vertical Separations Between Conductors on the Same Structures but on Different Crossarms.*

The vertical separations between conductors of the same or different voltage classification when carried on the same structure but on different crossarms shall not be less than the values given in Table 8 of this order.

Exception: (1) The provisions of this order do not apply to the vertical spacings between lines at different levels where men are not permitted to enter the spaces while the lines are alive.

(2) Trolley contact conductors and their associated feeders, which for convenience are carried at approximately the same level, may be carried at levels below signal lines if at least 4 feet below signal lines for public use and 2 feet below signal lines used only in the operation of supply lines.

Note: In general conductors of lines operating at the voltages indicated at the heads of columns are to be installed at levels above those at lower voltages to the left of the table when carried on the same structures with the exceptions in (f) and (g) of this order and in Orders 1221—b, 1254—a and 1273—d.

TABLE 8.—MINIMUM VERTICAL SEPARATIONS IN FEET BETWEEN LINE CONDUCTORS OF THE SAME OR DIFFERENT VOLTAGE CLASSIFICATION WHEN CARRIED ON THE SAME STRUCTURE BUT DIFFERENT CROSSARMS

Conductors at Lower Levels	Supply Conductors at Higher Levels				
	0 to 750 Volts	750 to 7,500 Volts (1)	7,500 to 15,000 Volts (1)	Different Utilities 15,000 to 50,000 Volts	Same Utility 15,000 to 50,000 Volts
	Feet	Feet	Feet	Feet	Feet
Signal lines	(3) 4	4	6	6	.....
Signal lines used in operation of supply lines	2	(2) 2	4	6	4
0 to 750 volts	2	2	4	6	4
750 to 7,500 volts	.....	2	4	6	4
7,500 to 15,000 volts	.....	.....	2	4	4

(Reference numbers refer to exceptions and additions to table.)

Exceptions and Additions to Table 8.

The specified clearances usually indicate the minimum vertical separation between parallel crossarms (center to center) at the pole, and

where these clearances are provided between the centers of the crossarms the clearance of the conductors supported thereon may be reduced below those given in the table by an amount not to exceed 8 inches where the tabular clearance is 2 feet or 4 feet, and by an amount not to exceed 12 inches when the tabular clearance is 6 feet.

The provisions of this order do not apply to the vertical spacings between conductors at different levels where men are not permitted to enter the spaces while the lines are alive.

(1) Where conductors are operated by different utilities a minimum vertical spacing between the respective conductor levels of 4 feet is recommended.

(2) This shall be increased to 4 feet when the signal conductors are carried above supply conductors unless the signal line conductor size is that required for grade C supply lines.

(3) In localities where the practice has been established of placing on jointly used poles, crossarms carrying supply circuits operating at less than 300 volts to ground and crossarms carrying signal circuits at a vertical separation less than that specified in the table, such existing construction (provided the minimum separation between the crossarms is not less than 2 feet) may be continued until the said poles are replaced; provided, however, that extensions to existing construction shall conform to the clearance requirement specified in the above table.

When signal wires are all in cable a supply crossarm carrying only wires operating at not exceeding 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 crossarm shall be at least 30 inches horizontally from the center of the pole and the cable be so placed as not to obstruct the climbing space. (See also Order 1225—a-3.)

(f) *Vertical Arrangement of Conductors.*

Supply conductors of the same circuit arranged vertically on separate crossarms may occupy the same crossarms with supply conductors of the next consecutive voltage classification (see Table 8 of (e) above) similarly arranged, provided the clearance (Order 1221) and climbing space (Order 1225) specified for the higher voltage are maintained at each level concerned. When so arranged, the minimum vertical separation between crossarms shall be that required in Table 8 of this order for the highest voltage concerned.

(g) *Vertical Racks.*

Conductors of circuits of less than 750 volts may be carried on vertical racks at one side of the pole where normal spans do not exceed 150 feet if the full width of climbing space is maintained past the rack and at least 4 feet above and below. (See Table 5, Order 1221, for necessary clearance from surface of poles.)

Order 1224. Conductors of Different Sags on the Same Supports.

(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 provided for by Orders 1221, 1222 and 1223, at the supports.

(b) *Readjustment of Sags.*

Sags shall be readjusted when necessary to accomplish the foregoing but not reduced sufficiently to conflict with the requirements of Order 1246.

Note: In cases where conductors of different sizes are strung to the same sag for the sake of appearance or to maintain unreduced clearances throughout storms, the chosen sag should be such as will keep the smallest conductor involved in compliance with the sag requirements of Order 1246.

Order 1225. Climbing Space.

(a) *Supply Lines Alone or on Joint Poles with Signal Lines.*

All poles or structures carrying crossarms supporting supply lines alone or supply and signal lines on joint poles shall be arranged and maintained so as to provide an unobstructed vertical climbing space on at least one side or corner of the pole or structure having dimensions horizontally each way as follows:

(1) With supply conductors alone of less than 300 volts to ground the climbing space shall be not less than 24 inches.

(2) With supply conductors alone of more than 300 volts to ground the climbing space shall be not less than 30 inches.

(3) When lines of voltages between 7500 and 15,000 volts are worked on or climbed through when alive a climbing space of at least 36 inches horizontally each way shall be provided.

(4) With signal conductors on the same pole and below supply conductors the same climbing space shall be provided through the signal conductors as required for the supply conductors immediately above.

(5) With signal conductors on the same pole and above supply conductors not exceeding 7500 volts the climbing space required for the supply conductors shall extend up to a point at least 4 feet above the highest supply conductors carried on the pole. If the supply conductors exceed 7500 volts this distance shall be 6 feet.

Exceptions: (1) *Where Men Do Not Ascend Beyond Conductors.* The above provisions do not apply if the unvarying practice and published operating rules of the employers concerned prohibit employes from ascending beyond the conductors of the given line unless the lines are killed or protected by suitable shields. In such cases if the conductors operate at less than 15,000 volts, a 24-inch climbing space is permitted.

(2) *Protected Vertical Conductors.* Vertical runs incased in suitable conduit or other protective covering (See Order 1226) and securely attached to the surface of the pole or structure and the pole or structure itself when included in one side or corner of this space when buck or reverse arm construction is used are not considered to obstruct the climbing space.

(3) *Protected Longitudinal Runs.* Longitudinal runs of cable or conductors are not considered to obstruct the climbing space if no supply line conductors carried on crossarms are within 4 feet above or below (See also Note (3), Table 8, Order 1223). Such cables or conductors must be protected when within 20 inches from pole center by suitable guard arms securely fastened to the pole, or by substantial insulating conduit, unless located above supply line conductors or at least 6 feet below. If grounded metal sheathed cables are uninsulated from metal supports attached to wood poles, similar protection shall be provided for such supports for at least 24 inches from the pole center.

Note: (1) It is recommended that climbing space of at least 24 inches horizontally each way be provided on poles carrying signal conductors only, when such signal conductors operate at voltages exceeding 150.

(2) Where double crossarms are not used on any one pole and all crossarms are parallel, it is recommended that the crossarms be on the same side of the pole.

(3) With lines of voltage of more than 15,000 volts the proper dimensions of the climbing space will depend upon the particular conditions.

(b) *Special Clearance for Longitudinal Runs.*

In cases where longitudinal runs of supply conductors not over 750 volts are supported near the surface of the pole as by brackets or racks or on pins close to the pole, unless they are located at levels at least 4 feet above or below other supply conductors carried on crossarms, sufficient side clearance from the pole center shall be provided for the line conductors on the adjacent crossarms to afford the full width climbing space for at least 4 feet above and below the longitudinal runs concerned.

(c) *Obstructions.*

All poles shall be kept as free as practicable from posters, bills, tacks, nails and other unnecessary obstructions. Through bolts shall be properly trimmed.

Order 1226. Clearances of Vertical and Lateral Conductors.

Exception: Provisions (a) and (d) do not apply to portions of a pole which workmen never ascend while the conductors in question are alive.

(a) *Climbing and Working Spaces.*

Vertical and lateral conductors, ground wires and metal sheathed cables shall not obstruct the vertical climbing spaces (see exceptions to Order 1225) or the lateral working space between line conductors at different levels (see also Order 1223) or interfere with the safe use of pole steps where such are installed.

(b) *Clearances Between Conductors and from Conductors to Surfaces of Structure.*

Vertical and lateral conductors which are rigidly supported on fixed supports shall have the minimum separations and clearances from other conductors, conduits, pole surfaces and guy, span or messenger wires provided below. Where not so supported greater separations and clearances shall be used. (See also (c), (d) and (e) below for exceptions.)

Note: This order is not intended to 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 enclosed in a metal sheath.

(1) From surfaces of supports and from other conductors of the same circuit 3 inches for 7500 volts or less, plus .25 inch for each 1000 volts over 7500 volts. (Highest voltage concerned should be used as basis for calculation. Also see exception under Note 2, Table 5, Order 1221.)

(2) From span, guy or messenger wires and from conductors of other circuits 6 inches plus 0.4 inch per kilovolt (highest voltage concerned), in excess of 7500 volts for supply conductors and 3 inches for signal conductors.

(3) From conductors on other supports as provided in Order 1227.

(c) *Vertical Supply Conductors Through Signal Conductors.*

(1) Vertical conductors including ground wires which are carried through a space occupied by signal circuits shall be inclosed in insulating conduit or in metal conduit or cable protected by an

insulating covering or wooden molding. The enclosure shall extend from a point at least 6 feet below the lowest signal conductor to a point at least 6 feet above the highest signal conductor or equipment if the supply voltage exceeds 7500 volts or to a point at least 4 feet above the highest signal conductor or equipment if the supply voltage is less than 7500 volts.

(2) In the latter case the distance above the highest signal conductor or equipment may be reduced to 2 feet if the supply voltage is less than 300 volts and 2 feet has been established as the vertical clearance. (See Exception 3 to Table 8, Order 1223.)

Exception: 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 so arranged that the cable shall be held at a distance of approximately 5 inches away from the surface of the pole and from any pole step.

(d) *Vertical Conductors Through Supply Conductors.* (See also (e) below.)

Vertical conductors of not more than 7500 volts shall clear the 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 of not more than 7500 volts when the latter are carried on or within 4 feet of the pole. If the vertical conductors are of more than 7500 volts this clearance shall not be less than 20 inches. If the supply line conductors are of more than 7500 volts the clearance from pole center shall apply for a distance not less than 6 feet above and below.

Exceptions: (See also (e) below.)

(1) Vertical and lateral supply conductors, including ground wires which are enclosed in insulated conduit or in metal conduit or cable having an insulating covering, or wooden moulding if wire is used having triple braid weatherproof insulation, whenever within 4 feet from open supply lines of less than 7500 volts or within 6 feet from open supply lines of more than 7500 volts may have less than the clearance specified above.

(2) Vertical and lateral conductors in metal sheathed cables and ground wires when installed on poles used only for supply lines and employing side arm construction when the lines are carried only on one side of the poles may have the insulating conduit or covering omitted.

(3) Vertical and lateral conductors of less than 7500 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 or brackets and so arranged that the cable shall be held at a distance of approximately 5 inches from the surface of the pole or any pole step.

(4) Vertical and lateral signal conductors may be attached directly to the pole by means of rings, knobs or brackets provided they are rubber insulated twisted pairs and do not come within 4 feet from open supply lines of less than 7500 volts or within 6 feet of open supply lines of more than 7500 volts. If distances are less than the above the conductors shall be incased in insulating conduit or in other substantial insulating and protective covering.

(e) *Mechanical Protection Near Ground.*

Where within 8 feet of the ground a suitable mechanical protective covering shall be provided over all vertical conductors, including lead sheathed cables. The protective covering shall be of wood molding or other insulating material if for the ground wire of a lightning arrester.

Exception: The covering may be omitted for cables and for ground wires having a triple braided weatherproof insulation in rural districts and for cables armored or installed in grounded metal conduit in urban districts.

(f) *Conductors not in Conduit.*

Conductors not incased in conduits shall have the same clearance from conduits as from other surfaces of structures.

Order 1227. Clearances of Conductors of One Line from Poles and Conductors of Another Line.

(a) *Clearances from Poles.*

Where conductors of one line are carried within 6 feet from a supporting structure of a second line, and are not attached thereto, the clearance between the conductors of the first line and any part of the supporting structure of the second line shall, if practicable, be not less than 3 feet at 60° F. and no wind. In no case should this clearance be less than the values required by Orders 1221 and 1222, 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.

(b) *Clearances from Conductors.*

The clearance in any direction, at 60° F. with no wind, of any conductor of one line from any conductor of a second and conflicting line shall not be less than required by Orders 1221 and 1222 for separation between conductors on the same support and shall not be less than 4 feet.

It shall be at least equal to the apparent sag of the conductor having the greater sag plus .2 inch for every 1000 volts of the highest voltage concerned.

Order 1228. Clearances from Buildings.

(a) *General.*

Conductors shall be so arranged and maintained as to hamper and endanger firemen as little as possible in the performance of their duties.

(b) *Ladder Space.*

Where buildings exceed 3 stories or 50 feet in height overhead lines shall be arranged where practicable so that a clear space or zone at least 6 feet wide will be left either adjacent to the building or beginning not over 8 feet from the building to facilitate the raising of ladders.

(c) *Clearance of Supply Lines of Not More Than 7500 Volts.*

(1) Supply conductors operating at voltages not exceeding 7500 (unless in grounded conduit or metal sheath cable or otherwise rendered inaccessible) shall be so arranged that they do not come nearer than 3 feet measured horizontally from any point on the surface of a building or its attachments, or nearer than 8 feet above the top of any building or above any balcony or other platform crossed over.

Exception: Service drops operating at less than 300 volts are exempted from this requirement for horizontal clearance and need not be more than 3 feet above building roofs which cannot readily be walked on.

2. Where the above clearances can not be provided or where supply conductors are placed near enough to windows, verandas, fire escapes or other ordinarily accessible places to be exposed to contact of persons, the conductors shall be properly guarded by conduit barriers or otherwise.

(d) *Clearance of Lines of More Than 7500 Volts.*

Conductors operating at voltages exceeding 7500 volts (unless in grounded conduit or metal sheathed cable or otherwise rendered

inaccessible) shall be carried at such height and distance from buildings as not to interfere with firemen in event of fire. If within 25 feet of a building they shall be carried at a height not less than that of the front cornice. The height shall be greater than that of the cornice as the wires come nearer to the building in accordance with the following table:

Distance of Wire from Building	Elevation of Wire above Cornice of Building
Feet	Feet
25	0
20	2
15	4
10	6
5	8
2½	9
0	10

Note: It is evident that where the roof of the building continues nearly in line with the walls, as in Mansard roofs, the height and distance of the line must be reckoned from the nearest point of the building instead of from the cornice.

(e) *Where Attached to Buildings.*

Where the permanent attachment of open supply conductors of any class to buildings is necessary for an entrance, conductors operating at over 300 volts to ground shall not be carried along or near the surface of the building unless they are guarded or made inaccessible and shall have separations from each other and clearances from building surfaces not less than those required by Table 5 of Order 1221—a for separation. (See also Section 132, Part 3.)

(f) *Crossing Roofs.*

(1) 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.

Order 1229. Clearances from Bridges.

(a) *Accessible Portions.*

Supply conductors operating at voltages less than 7500 (unless in grounded conduit or metal sheathed cable) shall be so arranged that they do not come within 3 feet from any readily accessible wing wall or other readily accessible portion of any bridge or its

attachments. For conductors operating at voltages above 7500 (unless in grounded conduit or metal sheathed cable) the minimum clearances shall be those required by (b) and (c) below.

(b) *Ordinarily Inaccessible Portions: Where Attached.*

Open supply conductors passing over, under, or near a bridge (other than brick, concrete, or masonry requiring infrequent inspection or repair) when attached thereto shall where practicable be so arranged that they do not come within the following distances of any bridge or abutment.

Operating Voltage	Clearance in Feet
0 to 2,500	0.5
2,500 to 5,000	1.0
5,000 to 7,500	3.0
7,500 to 15,000	5.0
15,000 to 50,000	7.5

(c) *Ordinarily Inaccessible Portions: Where Not Attached.*

Open supply conductors passing over, under or near a bridge (other than brick, concrete, or masonry requiring infrequent inspection or repair) and not attached thereto, shall be so arranged that they do not come within the following distances from any portion of the bridge or abutment.

Operating Voltage	Clearance in Feet
Up to 7,500	3.0
7,500 to 15,000	5.0
15,000 to 25,000	7.5
25,000 to 35,000	9.0
Exceeding 35,000	12.0

Note: The clearances as given above are minimum and should be increased as much as practicable.

(d) *Separations.*

Where supply conductors attached to bridges are supported at frequent intervals, their separation may be less than that specified in Orders 1221 and 1222, but not less than that required by Order 1221 for clearances from surfaces of poles and crossarms or less than the following:

Span Length	Separation in Inches
Up to 20 feet	6
20 to 50 feet	9

(e) *Trolley Contact Conductors.*

Trolley contact conductors attached to the under surface of bridges shall be provided with a substantial inverted trough of non-conducting material or other suitable means shall be taken to keep the trolley pole from making connection between the trolley contact conductor and the bridge structure.

(f) *Warning Signs.*

The pin-supporting structure attached to bridges shall be plainly marked with the name, initials, or other identifying mark of the utility responsible for the attachment and, in addition, when the voltage of the conductors exceeds 750 volts, by the following or equivalent sign "DANGER—DO NOT TOUCH."

SECTION 123. CLASSIFICATION OF CIRCUITS ACCORDING TO GRADE OF CONSTRUCTION REQUIRED

Order 1230. Required Grade of Overhead Line Construction and Arrangement of Levels. (See also Order 1236.)

(a) *Various Conditions of Hazard.*

(1) Supply and signal lines shall have mechanical construction of the grade designated as A, B, C, D, or E, depending upon the hazards involved, under the following conditions:

(I) When concerned in crossings or conflicts.

(II) Where carried on the same supports with other lines.

(III) In some cases where carried through urban districts.

(2) The conditions determining each grade of construction are defined in the following orders of this section.

(3) Where none of these conditions exist, no specified grade of mechanical construction is required, but the general requirements given in Sections 120, 121, and 122 must be met.

(4) Grades of construction A, B, and C are described in the orders of Section 124. Grades of construction D and E are described in Section 128. In any case where two or more of the conditions listed below exist, the grade of construction shall be the highest called for under any item applying.

(5) Where one line crosses over or conflicts with another the grade of the upper line shall not be less than the grade required for the lower line.

Note: The orders referring to signal lines apply to all signal lines except those used in the operation of supply lines, and their application to these is determined by one of the construction methods applied to signal lines and to neighboring lines as given in Order 1289.

(b) *Double Crossings.*

Where a line crosses in one span over two other lines, the strength of construction shall be not less than would be required if either of the two lower lines crossed the other.

Note: For example, if a 2300 volt line crosses in the same span over a signal line and a direct-current trolley line of more than 750 volts the 2300 volt line would be required to comply with Grade A construction at the crossings. This is a double crossing and introduces a greater hazard than where the upper supply line crosses the signal line only.

(c) *Arrangement of Relative Levels.*

(1) Where supply and signal lines or supply lines of different voltage classification cross each other or are in conflict, or are on the same poles or towers, the highest voltage lines shall preferably be carried at the higher levels.

Note: It is recommended that, where practicable, lines be arranged, by mutual agreement of the utilities concerned, at standardized levels throughout a given community, in order to minimize difficulties when new crossings or extensions to existing lines are to be installed. (See also Table 4, Order 1220 for relative levels.)

(2) Where circuits of different classification are concerned in a crossing, conflict, or common use of poles, the construction for the circuit at the higher level shall be of at least as high a grade as would be required for the circuit at lower level if it were above the other.

(d) *Avoidance of Conflict.*

(1) 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.

(2) If this is impracticable, then the conflicting line or lines shall be built of the grade of construction required by the orders for a conflicting line or the two lines shall be combined in a single pole line. (See also Orders 1234, 1236 and 1272.)

Order 1231. Supply Lines in Urban Districts.

(a) *Grade B.*

The following supply lines in urban districts shall comply with the requirements of Grade B, except as given in (b) and (c) below:

(1) Lines of more than 7500 volts.

(2) Lines of any voltage where carried above lines of more than 7500 volts.

(b) *Grade C.*

The following supply lines in urban districts shall comply with the requirements of Grade C, except as given in (c) below:

(1) Lines of more than 7500 volts if in cable having permanently grounded continuous metal sheath or armor and complying with the requirements of Order 1274.

(2) Lines of voltages between 750 and 7500.

(3) Lines of less than 750 volts when carried above lines of voltages between 750 and 7500.

(c) *No Specified Grade.*

The following supply lines in urban districts need comply only with the general requirements of Sections 120, 121 and 122.

(1) Lines of voltages between 750 and 7500 if in cable having permanently grounded continuous metal sheath or armor and installed in compliance with the requirements of Order 1274.

(2) Supply lines of less than 750 volts where alone or concerned only with signal lines or with supply lines of less than 750 volts or both.

(3) Lines on fenced rights of way, except where crossing over, conflicting with, or higher on joint poles with the conductors of other lines.

(d) *Constant-Current Circuits.*

Constant-current circuits shall meet the requirements for circuits of their nominal full-load voltage.

Order 1232. Supply Lines in Rural Districts. (See also Order 1252.)

(a) *Grade C.*

(1) When either of two supply lines in rural districts, one of more than 7500 and the other of less than 750 volts, crosses, conflicts with, or has common poles with the other, the upper one shall comply with the requirements of Grade C, unless the line of higher voltage is in cable having permanently grounded continuous metal sheath or armor and is installed in compliance with Order 1274.

(2) Constant-current circuits are included in this order, the voltage being the nominal full-load voltage.

Exception: Supply lines of more than 7500 volts are exempted from this requirement if crossing over or conflicting only with service connections from supply lines.

(b) *No Specified Grade.*

(1) Supply lines of more than 7500 volts in rural districts, where alone, or where concerned only with supply lines of more than 750 volts, need comply only with the general requirements of Sections 120, 121 and 122.

(2) Supply lines of less than 7500 volts in rural districts, except as covered in (a) above, need comply only with the general requirements of Sections 120, 121 and 122.

Order 1233. Supply Lines Crossing Over Railways. (See also Section 126.)

(a) *Grade A.*

Supply lines carried over railways, operated by steam, electric, or other motive power, except as provided in (b) and (c) below, shall comply with the construction requirements of Grade A.

(b) *Grade B.*

Supply lines carried over minor tracks included in the following list shall comply with the requirements of Grade B.

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

(2) Branches on which no regular schedule of operation is maintained.

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

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

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

(c) *Street Railway Crossings.*

Supply lines crossing over street railways on traveled portions of highways need conform only to general requirements, but when carried over trolley contact conductors shall have the same grade of construction as where crossing over supply lines of equal voltage. (See Orders 1231 and 1232.)

Order 1234. Supply Lines in Crossings, Conflicts, and Joint Use of Poles with Signal Lines.

Exception: It is not intended that the requirements of (a-1), (b-1), and (c-1) below shall apply where the signal lines concerned are individual twisted-pair drop wires only.

(a) *Grade A.*

Supply lines and signal lines under the conditions specified below shall comply with the requirements of Grade A.

(1) Constant-potential alternating-current supply lines normally operating at more than 7500 volts between conductors or

4400 volts to neutral or ground, or constant-current circuits of more than 10 amperes, or direct-current trolley circuits of more than 750 volts to ground where at higher levels and crossing over, conflicting with, or having joint poles with signal lines except as noted in (b-3) below for certain signal conductors.

(2) Signal lines carried at higher levels than the supply lines specified in (1) above where involved in crossings, conflicts, or joint use of poles.

(b) *Grade B.* (See exception above.)

Supply lines and signal lines under the conditions specified below shall comply with the requirements of Grade B.

(1) Constant-potential alternating-current supply lines normally operating at voltages between 5000 and 7500 between conductors or between 2900 and 4400 volts to neutral or ground, or constant-current circuits of between 7.5 and 10 amperes, where at higher levels and crossing over, conflicting with, or having joint poles with signal lines (except as noted in (c-3) below for certain signal conductors).

(2) Signal lines carried at higher levels than the supply lines specified in (1) where involved in crossings, conflicts, or joint use of poles.

(3) Supply lines specified in (a-1) above when at higher levels and crossing over, conflicting with, or having joint poles with signal lines carrying not more than four wires used mainly for local exchange service, or only subscribers' loops, or not more than two local telegraph or fire alarm wires.

(c) *Grade C.* (See exception above.)

Supply lines and signal lines under the conditions specified below shall comply with the requirements of Grade C.

(1) Constant-potential alternating-current supply lines normally operating at voltages between 750 and 5000 between conductors or voltages between 440 and 2900 to neutral or ground and constant-current circuits of not more than 7.5 amperes and supply lines of more than 5000 volts in cable having permanently grounded continuous metal sheath or armor (and installed in compliance with Order 1274) where at higher levels and crossing over, conflicting with, or having joint poles with signal lines.

(2) Signal lines carried at higher levels than the supply lines specified in (1), except as smaller conductor sizes are permitted by order 1283—d.

(3) Supply lines specified in (b-1) above when at higher levels and crossing over, conflicting with, or having joint poles with signal lines carrying not more than four wires used mainly for local exchange service or only subscribers' loops, or not more than two local telegraph or firm alarm wires.

(4) Signal lines carried over trolley contact conductors of less than 750 volts shall comply with Grade C requirements as to conductor sizes and sags except as noted in Order 1286.

Order 1235. Signal Lines Crossing Over Railways. (See also Section 128.)

(a) *Grade D.*

Telephone, telegraph, and other signal lines carried over railways operated by steam, electric, or other motive power shall, with the exceptions noted below in paragraphs (b), (c), (d), and (e), of this order comply with the construction requirements of Grade D.

(b) *Grade E.*

Signal lines carried over minor tracks included in the following list shall conform to the requirements of Grade E.

(1) Spurs less than 2000 feet long, and not exceeding two tracks in the same span.

(2) Branches on which no regular schedule of operation is maintained.

(3) Narrow-gage tracks or other tracks on which standard rolling stock can not, for physical reasons, be operated.

(4) Tracks used only temporarily for construction or similar purposes for a period not exceeding one year.

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

(c) *Street Railways.*

Signal lines carried over street railways not having overhead trolley contact conductors, need comply only with the general requirements for signal lines alone. (See also Order 1288 and Sections 121 and 122.)

(d) *Trolleys.*

Where signal lines cross over trolley contact conductors of less than 750 volts to ground, they shall comply with the requirements of Order 1283—d as to conductor sizes and sags. For

trolley contact conductors of more than 750 volts to ground, the requirements for crossing over supply lines must be met, namely, Grade A for direct-current trolley lines, and Grade A, B, or C for alternating-current trolley lines, depending upon the voltage.

(e) *Signal Lines Classed as Supply Lines.*

Signal lines which are classed as supply lines shall, where crossing over railways, comply with the construction requirements of Order 1233. (See Order 1289.)

Order 1236. Cooperation to Avoid Hazard. (See also Section 127.)

Utilities or parties responsible for location or construction of new facilities or change in voltage, construction or operating method, shall consult with other utilities or parties between whose facilities and their own conflicts may now or later be created for which precautionary construction measures will be necessary to prevent hazard, and the parties concerned shall cooperate with a view to preventing hazard.

Note: When supply or signal lines are projected which will parallel existing lines on or along the same highway, street, alley, railway or other rights-of-way the new construction should, unless joint construction is recommended, be located on the opposite side of the highway, street, alley, railway or right-of-way from that occupied by existing line or lines of the other kind, and on the same side with its own kind.

SECTION 124. OTHER REQUIREMENTS FOR SUPPLY LINES OF GRADES A, B, AND C

Order 1240. General Strength Requirements.

(a) *Preliminary Assumptions.*

In the calculation of all stresses no allowance shall be made for deformation, deflection, or displacement of any part of the supporting structures.

(b) *Transverse Strength.*

The paragraphs which specify the transverse strength requirements for supporting structures relate to Grade B construction unless otherwise stated. For Grade C the transverse strength shall be not less than two-thirds of that required for

Grade B. For Grade A the transverse strength shall be at least 50 per cent greater than that required for Grade B. See also Appendix A.

Order 1241. Calculation of Stresses in Conductors.

In computing the longitudinal stresses upon conductors and their supports, and the sags corresponding to given limiting stresses in conductors, the loading shall be assumed as the resultant loading due to the weight of the conductor plus the added weight of a layer of ice one-half 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. The minimum temperature shall be assumed as 0° F.

Note: Ice is assumed to weigh 57 pounds per cubic foot.

Order 1242. Calculation of Loads upon Line Supports.

(a) *Assumed Vertical Loading.*

The vertical loads upon poles, towers, and crossarms shall be taken as their own weight, plus the weight of the ice-covered conductors supported. The thickness of ice coating shall be taken as one-half inch. (See Appendix B, Table 35, for vertical loads due to conductors.)

(b) *Assumed Transverse Loading.*

In computing the stresses in poles and towers the loading shall be taken as that due to 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 the conductor when covered with a layer of ice one-half inch in radial thickness and of the poles and towers without ice covering. (See Order 1272—d for certain signal conductor exemptions.)

Note: For flat surfaces the assumed unit pressure should be increased by 60 per cent. Where latticed structures are concerned the actual exposed area of one lateral face should 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, if desired.

(c) *Average Span Lengths.*

The calculated loads upon poles, towers and crossarms 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, except that the average value taken shall in no case 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.

(d) *Average of Three Poles.*

A pole not individually meeting the transverse strength requirements will be permitted when reinforced by a stronger pole on either 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.

Exception: 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.

(e) *Actual Span Lengths and Pole Strengths at Crossings.*

In case, however, of crossings over railroads or signal lines (other than those mentioned in Order 1234—b-3 and c-3), the actual lengths of the two spans adjacent to the two structures concerned, and the actual strengths of the crossing poles, shall be used.

Order 1243. Strength of Steel Poles and Towers and Other Metal Supports.

(a) *Loads and Limiting Stresses.*

(1) Steel supports, steel towers, and metal poles, together with their foundations, and guys when used, shall be so designed and constructed as to withstand the stresses due to the loads assumed in Order 1242. Under those loads the calculated stresses in the steel members and in the guys shall not exceed the following values, which are intended to be limiting unit stresses, not in excess of the yield point, beyond which the structures as a whole would be liable to failure.

Structural Steel:
- Tension ..... 27,000 pounds per sq. inch
- Shear ..... 24,000 pounds per sq. inch
- Compression ..... $27{,}000 - 90\frac{L}{r}$

Bolts, Rivets, Pins:
- Shear ..... 24,000 pounds per sq. inch
- Bearing ..... 48,000 pounds per sq. inch
- Bending ..... 36,000 pounds per sq. inch
- Guys ..... One-half the ultimate strength

(2) These values for structural steel are for material having an ultimate tensile strength between 55,000 and 65,000 pounds per square inch and a yield point not less than 50 per cent of the ultimate strength.

Note: Guys are made of various grades of steel wire, the lowest grade generally having a strength of about 60,000 pounds per square inch while the highest grade has a strength of 180,000 pounds or more per square inch.

(b) *Guys.*

The use of guys to obtain compliance with these requirements is regarded as generally undesirable. When the guys are necessarily used, the steel supports or towers unless capable of considerable deflection shall be regarded as taking all of the stress in the direction in which the guy acts, up to their safe working load, and the guys shall have sufficient strength to take the remainder of the assumed maximum stress. (See Order 1212—c for flexible towers.)

(c) *Total Minimum Strength.*

Steel towers shall have a minimum strength sufficient, if all conductors are removed, to withstand a transverse force three times that computed for the tower alone.

Note: Unless sample structures are tested, or similar structures 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 the rule.

(d) *Foundations.*

Steel towers or poles shall 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.

Note: 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 stresses under the assumption of average conditions of climate and soil.

(e) *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, which shall be able to withstand the combined longitudinal tension of all conductors up to 10,000 pounds plus one-half the excess above 10,000 pounds.

(f) *Thickness of Steel.*

(1) Steel poles or towers of Grades A, B, and C shall have no less thickness of metal in members than the following:

Legs, galvanized, 3/16 inch; other members 1/8 inch.

Legs, painted, 1/4 inch; other members, 1/4 inch.

(2) Such steel poles or towers, including footings, shall be so constructed that all parts are accessible for inspection, cleaning and painting when necessary and that pockets are not formed in which water can collect. The ratio of L, the unsupported length of a compression member to r, the least radius of gyration of the member, should generally not be greater than 150 for legs and 200 for other members having figured stresses.

Note: The straight line formula given under (a) above for the allowable stress in compression automatically limits the stresses in steel members to safe values even though the ratio L/r is greater than the values given above. In other words, for larger values of L/r, due to increasing L, the value of the stress is reduced so much that no hazard can result.

(g) *Protective Covering or Treatment.*

All iron or steel poles, towers, or supporting structures, and 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 1244. Strength of Wood or Concrete Supports.

(a) *New Poles.*

Wood and reinforced concrete poles and their foundations and guys (when used) shall, when installed, be of such material and dimensions as will withstand the loads assumed in Order 1242, without the stresses under these loads exceeding 50 per cent of the assumed ultimate strengths of the material. (For method of computing strength of construction see Appendix B.)

(b) *Maintenance.*

Wood poles shall be replaced or reinforced when their strength has decreased to two-thirds that required for new installations for Grades A and B construction, and to one-half for Grade C construction.

(c) *Selected Poles.*

Except for crossings over railroads and over signal lines (other than those mentioned in Order 1234—b-3 and c-3) two-thirds of the movement on wood poles (calculated as in Order 1240 and 1242) due to transverse wind pressure may be used in finding the stresses in the poles, under the following circumstances:

(1) The poles shall be specially selected clear wood poles.

(2) They shall have dimensions not less than those listed in Tables 41, 42 and 43, Appendix B-4. These dimensions correspond to poles usually classified as Class A for Grade A and as Class B for Grades B and C.

(3) They shall be systematically inspected and maintained by treatment, repair, or replacement in accordance with 1244—b.

(d) *Minimum Pole Sizes.*

Wood poles in grades of construction A, B and C shall be of selected timber free from observable defects that would decrease their strength and durability and shall have no less nominal top diameters than 6 inches, except that for Grade A a minimum of 7 inches is required.

Note: See Appendix B for data for computing transverse and longitudinal strength required for line supports.

(e) *Guys.*

When guys are used to meet the strength requirements for wood or concrete poles, they shall be considered as taking, in the direction in which they act, the horizontal component of the entire load, the poles, acting as struts, resisting the vertical component.

Order 1245. Strength of Crossarms and Conductor Fastenings.

(a) *Crossarms of Selected Yellow Pine or Fir.*

The minimum cross-sectional dimensions of selected yellow pine or fir crossarms for Grades A, B and C construction shall be as follows:

	For Grades A and B	For Grade C
2 or 4 pin	3 x4 in.	2¾x3¾ in.
6 or 8 pin	3¼x4¼ in.	3 x4 in.

Exception: (1) Grade C signal line crossarms may be 2¾x3¾ inches for 6 pins, and 3x4 inches for 10 pins.

(2) If of other material they shall have at least equal strength.

(b) *Crossarm Strength.*

Crossarms for construction of Grades A, B, or C shall, when installed, withstand the vertical loads specified in Order 1242 without the stress under these loads exceeding 50 per cent of the assumed ultimate strength of the material. They shall also 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.

(c) *Bracing.*

Crossarms shall be securely supported, by bracing, if necessary, so as to safely support all other loads to which they may be subjected in use, including linemen working on them. Any crossarm or buckarm 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. In general, they shall be maintained at right angles to the axis of the pole and to the direction of the attached conductors, and at wire crossovers shall be attached to that face of the structure away from the crossing, unless special bracing or double crossarms are used.

Note: Double crossarms 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 crossarms might provide sufficient strength. To secure extra strength, double crossarms are frequently used, and crossarm guys are sometimes used.

(d) *Pins and Conductor Fastenings.*

Pins, ties, and other conductor fastenings for Grades A, B and C construction shall have sufficient strength to withstand the unbalanced tension in the conductor, up to a limit of 700 pounds per pin or fastening.

Note: Tie wires or fastenings should have no sharp edges or burrs at contacts with the conductors.

(e) *Height of Pin.*

The height of the pin and of the conductor fastenings and the material and cross section of the pin shall be so chosen as to afford the required strength.

Note: The method of attaching conductors by suitable ties to single, pin-type insulators mounted on 1½x9 inch wood pins of locust or equivalent wood will usually provide strength up to 1000 pounds conductor tension with the conductor 3.5 inches above the crossarms. Suitable steel pins afford greater strength both for the pins and for the crossarms.

Order 1246. Conductors—Material, Minimum Sizes, and Sags.

(a) *Material.*

All conductors of Grades A, B, or C 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.

(b) *Minimum Sizes.*

Supply conductors (including lightning protection wires paralelling line conductors) shall not be smaller than indicated in the following table, except that longer spans may be used with any listed conductor size if the separations and clearances given in Section 122 and the sags given in Appendix A are correspondingly increased.

TABLE 9.—MINIMUM ALLOWABLE CONDUCTOR SIZES FOR SOLID OR STRANDED CONDUCTORS

A. W. G. for Copper and Aluminum; Steel W. G. for Steel.

MEDIUM OR HARD DRAWN COVERED COPPER WIRES

Grade	Limiting Span Length in Feet			
	150	175	200	300
A & B	6	4	4	2
C	8	6	4	2

MEDIUM OR HARD DRAWN BARE COPPER WIRES

Grade	Limiting Span Length in Feet					
	150	175	200	300	400	500
A & B	6	4	4	4	2	2
C	8	6	4	4	2	2

SOFT DRAWN COPPER WIRES

Grade	Limiting Span in Feet		
	150	175	200
A	4	2	1
B	4	2	2
C	6	2	2

STEEL WIRES

Grade	Spans 150 Feet or Less	Spans Exceeding 150 Feet
A & B	6	4
C	9	6

ALUMINUM WIRES WITHOUT STEEL REINFORCEMENT

Grade	Spans 150 Feet or Less	Spans Exceeding 150 Feet
A, B & C	1	0

ALUMINUM WIRES WITH STEEL REINFORCEMENT

Grade	Spans 150 Feet or Less	Spans Exceeding 150 Feet
A, B & C	6	4

Note: For sizes and material requirements of supply service leads see Order 1219.

(c) *Sags and Maximum Tensions.*

In grades of construction A, B or C conductors of hard, medium and soft-drawn copper and steel shall have normal sags at 60° F. with no wind as nearly as practicable to those given in the tables of Appendix A.

Exception: Less sags than those listed may be used if pins, fastenings, crossarms and poles of sufficient strength to withstand the corresponding increase in longitudinal stresses are used, but sags shall not be so decreased from the tabulated values, that, under the maximum assumed loading, the tension will exceed 50 per cent of the breaking strength of the conductors concerned for Grades A and B construction, and 60 per cent for Grade C construction.

Note: (1) The sags given for copper in the tables are based upon experience and are designed to give the best results from the standpoint of safety and continuity of service.

(2) In order to minimize the danger from wires swinging together and to permit the moderate pin spacings and crossarm 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. Longer spans may, however, be used with any listed conductor size if separations and clearances (given in Section 122), and the sags given in Appendix A are correspondingly increased. It is recommended that medium hard-drawn copper wire be used instead of soft in new construction, especially for sizes smaller than No. 2.

(3) 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.

(4) Copper wire does not have so sharply defined a yield point as steel, but for practical purposes the yield point may be considered as that point beyond which the wire is permanently elongated and the sag permanently increased. 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.

(d) *Taking up Slack.*

Slack shall be taken up when, because of the permanent elongation of the wire or movement of supporting structures, the initial sags have so increased that the clearances or separations of conductors are materially below the requirements of the rules.

Note: As soft copper stretches more than medium or hard, the taking up of slack will be necessary chiefly in lines where soft wire is used.

Order 1247. Line Insulators for Grades A and B Construction.

(a) *High Voltage Insulators.*

Insulators for operation on supply lines at voltages exceeding 7,500 volts shall be of porcelain or other material which will give equally good results in respect to mechanical and electrical performance and durability.

Note: It is recommended that such insulators be marked by the maker with a classification number and maker's name or trade-mark, the marks being so applied as not to reduce the electrical or mechanical strength of the insulator.

(b) *Strain Insulators.*

Where strain insulators are used they shall have the same electrical strength as other insulators on the line when under the normal mechanical stresses to which they may be subjected.

(c) *Insulators at Grounded Structures.*

Wherever wood pins and crossarms or other ungrounded supports are used within five spans of a crossing span at which the line conductors are attached to grounded metal pins, grounded crossarms, steel bridges, steel towers, or other grounded structures, the insulators at the grounded supports shall be capable of withstanding without flash-over a voltage 50 per cent higher than those used at adjacent ungrounded supports.

Exception: Where the supporting structures for the crossing span are the same with respect to grounding as for the other parts of the line, the insulators used may also be the same.

(d) *Ratio Flash-Over to Puncture Voltage.*

Insulators shall be so designed that their dry flash-over voltage is not more than 75 per cent of their puncture voltage at a frequency of 60 cycles per second.

(e) *Factory Tests.*

Insulators shall be capable of withstanding without flash-over at a frequency of 60 cycles per second the values given in the following table:

TABLE 10

Voltage of Circuit	Test Voltage	
	Dry	Wet
750	5,000	3,500
2,300	11,000	8,000
4,000	17,000	13,000
6,600	27,000	20,000
7,500	30,000	22,000
11,000	40,000	30,000
22,000	75,000	55,000
33,000	105,000	75,000
44,000	135,000	95,000
55,000	160,000	115,000
66,000	185,000	135,000
88,000	235,000	170,000
110,000	285,000	200,000
150,000	375,000	225,000
200,000	490,000	250,000

Note: (1) By the term "wet" is meant a condition equivalent to a precipitation of one-fifth inch of rain per minute at an angle of 45 degrees to the axis of the insulator.

(2) Each insulator for use on lines operating at voltages in excess of 15,000 should be subjected to a routine factory dry test at the values given in table above for a period of 3 minutes at a frequency of 60 cycles or to any other test sanctioned by good modern practice, such as high frequency tests.

(f) *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 1248. Special Transverse Strength Requirements.

(a) *Alternative Construction in Special Cases.*

In the case of structures of Grades A or B construction where because of very heavy or numerous conductors or relatively long spans the transverse strength requirements of this section cannot 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 shall 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:

(1) 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.

(2) 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.

(3) 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.

(b) *Strength of Crossarms and Pins.*

The crossarms, insulator pins, and conductor fastenings connected to the structure at each end of the transversely weak section in lines of grades A and B construction shall be such as to withstand, under the conditions of loading prescribed in Order 1241, an unbalanced load equivalent to the combined pull in the direction of the transversely weak section of all the conductors supported up to 10,000 pounds plus one-half the excess for grade A, or plus one-fourth the excess for grade B.

Note: If the unbalanced tension in any conductor does not exceed 1000 pounds, the necessary strength will usually be provided by the use of single wood pins, and if the tension does not exceed 2000 pounds, by the use of double wood pins, provided the lever arm of the pin does not exceed 3.5 inches. (See Appendix A for tensions.)

Order 1249. Special Longitudinal Strength Requirements for Sections of Grades A and B Construction in Lines of a Lower Grade of Construction (or adjacent to Angles or Dead Ends).

(a) *Required Strength.*

The supporting structures (including poles, towers, crossarms, insulator pins, and conductor fastenings) for the ends of the

higher grade section of the line shall be constructed to withstand without failure under the conditions of loading prescribed in Order 1241 a longitudinal load equivalent (except as noted in d) to the combined pull in the direction of this section of all the conductors and wires supported, the pull of each conductor or wire being taken as the tension therein due to the prescribed loading. Where it is difficult to increase the longitudinal strength, the longitudinal stresses shall be reduced by increasing the conductor sags. This may require greater conductor separation. (See Orders 1221, 1222, and 1223.)

Exception: 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.

Note: (1) 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 will be necessary to increase the normal clearances specified in Order 1220 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 (a) above. The requirements of (a) are usually met by placing supporting structures of the required longitudinal strength at either end of the higher grade section of the line.

(2) 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.

(b) *Modified Strength Requirements for Heavy Lines.*

(1) In cases where the line is approximately straight on both sides of the section of higher grade and in line with it, the strength of each pole or each crossarm shall be such as to withstand the combined tension in the conductors up to 10,000 pounds combined pull, plus one-half the excess above 10,000 pounds for grade A, and plus one-fourth the excess for grade B, if the line on one or both sides of the special construction should fail. In cases where, due to change of direction of the line or because of dead ends the longitudinal stresses in the conductors of the stronger section are

not normally balanced by the conductors of the line beyond this construction, the construction shall be such as to withstand the total combined tension.

(2) 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 stresses.

SECTION 125. REQUIREMENTS FOR SUPPLY LINES, INCLUDING ELECTRIC RAILWAY FEEDERS

Order 1250. Compliance with Other Orders.

(a) *Grade B or C Construction.*

In addition to the requirements of Sections 120, 121, and 122, the requirements of this section shall be met by all supply lines in urban and rural districts where a definite grade of construction B, or C is required by Section 123, except in the important cases of crossings over railways or signal lines, conflicts, and the joint use of poles, which are covered by Sections 126 and 127.

(b) *Special Strength.*

Special longitudinal strength requirements are made in Order 1249 for crossings of supply lines of less than 7500 volts and of cabled supply lines exceeding 7500 volts over supply lines of more than 7500 volts, in urban districts.

(c) *Dead Ends.*

Where supply lines of more than 7500 volts in urban districts come to dead ends or to changes in line direction (even where no crossing exists) they shall have construction complying with the longitudinal strength requirements of Order 1249.

(d) *Clearances.*

For clearances of conductors and wires above roadways, railways and footways, and from other conductors and wires see Orders 1220, 1257, and 1258.

Order 1251. Supply Lines in Urban Districts.

(a) *Lines of Less Than 750 Volts.*

(1) Supply lines of less than 750 volts in urban districts where alone, or where crossing over, conflicting with, or where higher and on common poles with other supply lines of less than 750 volts need only comply with the general requirements of Sections 120, 121, and 122.

(2) If the lower supply lines have a voltage greater than 750 volts and are not in cable having permanently grounded continuous metal sheath or armor and are not installed in compliance with Orders 1274—c, d, e and f, both lines shall comply with the requirements of grade C; if the lower supply lines are of more than 7500 volts and not in such cable both lines shall comply with the requirements of grade B.

(b) *Lines of Voltages Between 750 and 7500.*

(1) Supply lines of voltages between 750 and 7500 in urban districts, where alone, or where crossing over, or conflicting with, or where higher on common poles with, other supply lines of not more than 7500 volts shall comply with the construction requirements of grade C, as given in Section 124, unless the supply lines are in cable having permanently grounded continuous metal sheath or armor and are installed in compliance with Orders 1274—c, d, e, and f, in which case no grade is required.

(2) If the lower supply lines have a voltage greater than 7500 and are not in such cable, both shall comply with the construction requirements of grade B.

(c) *Lines of More Than 7500 Volts.*

Supply lines of more than 7500 volts in urban districts where alone, or on the same poles with other supply lines of any voltage, or crossing or conflicting with such lines, shall comply with the construction requirements of grade B.

Exception: Such lines if in cable having permanently grounded continuous metal sheath or armor and installed in compliance with Order 1274 need comply only with the construction requirements of Grade C.

Order 1252. Supply Lines in Rural Districts.

(a) *No Grade.*

Where supply lines of any voltage in rural districts are not concerned with crossing of railways or signal lines, or conflicts or joint use of poles with signal lines, no grade of construction is required for conductors or supports, except as noted in (b) below. Such lines are subject only to Sections 120, 121, and 122 for isolation, guarding, clearances, and pole arrangements, etc.

(b) *Grade C.*

When either of two supply lines in rural districts, one of more than 7500 volts and the other of less than 750 volts, crosses, conflicts with, or has common poles with the other, the upper one

shall be of grade C, unless the line of higher voltage is in cable having permanently grounded continuous metal sheath or armor and is installed in compliance with Order 1274—c, d, e, and f.

Order 1253. Constant-current Lines.

Where supply lines only are concerned, constant-current lines are included with constant-potential lines and graded by the nominal full-load voltage of the circuit concerned.

Order 1254. Common Use of Poles by Different Supply Lines.

(a) *Relative Levels.*

Poles or towers used in common by supply lines of different voltage classification, including trolley feeders, whether owned by the same or different utilities, shall have all supply lines arranged as to relative levels, separations, and clearances according to the requirements of Section 122.

Exception: Where poles are used in common by separately owned utilities each of which may have supply conductors of different voltages on the same pole, supply conductors of a lower voltage of one utility may be placed at a higher level than those of a higher voltage of another utility in order to admit of keeping each utility's supply conductors in adjacent positions on the pole, provided that:

(1) Conductors of a lower voltage classification shall never be at a higher level than those of a higher classification, unless on the opposite side of the pole, or

(2) that a vertical spacing not less than 4 feet is maintained between the nearest line conductors of the respective utilities, and this spacing be identified if necessary as a division space.

Note: In general the lines of higher voltage should be placed above those of lower voltage. This arrangement will often avoid the necessity for increasing the grade of construction of the crossarms, pins, and fastenings for the lower voltage conductors.

(b) *Grade of Construction.*

(1) Poles or towers used in common by supply lines, as noted in (a), shall have the grade of construction determined by Section 123 for the highest voltage lines carried on such poles or towers, all conductors of all voltages being included in the computations of stresses on the poles or towers.

(2) The crossarms, pins, and fastenings of conductors on poles or towers used in common by supply lines, as noted in Order 1254—a, shall have the grade of construction determined by Section 123 for the lines carried by the crossarm, pin, or fastening in

question, according to their relation to other lines carried on the poles or towers.

(c) *Conductor Size and Sag.*

The size and initial sag of each conductor shall be determined by its own voltage and the grade of construction required for it, according to its relation to other conductors carried on the pole or tower.

Note: The different conductors on a commonly used pole may therefore be subject to different grades of construction requirements, the grade necessary for any crossarm or pole being the highest required for any conductor carried, by Section 123.

(d) *Trolley Wires.*

Where a trolley contact conductor is supported on a commonly used pole, it shall be included in the computation of transverse stress on the structure.

Order 1255. Electric Railway Feeders and Contact Conductors.

(a) *Trolley Feeders as Supply Lines.*

Except where specifically exempted (as for clearance and elevation in rules for common use of poles in this section and in Section 122) trolley feeders shall be considered and constructed in all respects as supply lines of equal voltage.

(b) *Third Rails.*

Third rails shall be protected where not on fenced rights of way by overlapping guards composed of wood or other suitable material.

(c) *Trolley Contact Conductor Supports.*

All overhead trolley contact conductors shall be so supported and arranged that the breaking of a single conductor fastening will not allow the trolley conductor or live span wire or current-carrying connections to come within 10 feet from the ground or from any platform accessible to the general public. Span wire insulation for trolley contact conductors shall comply with Order 1213—f.

(d) *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 so suspended that if broken at a single point it cannot fall within 12 feet from the ground or any platform accessible to the general public.

(e) *Supply Lines Over Trolley Contact Conductors.*

Supply conductors carried over trolley contact conductors shall conform to the same requirements as where crossing over supply lines of equal voltage whether in urban or rural districts.

Order 1256. Electric Railway Construction.

(a) *Assuring Against Loss of Power at Railway Crossings.*

Unless electric-railroad systems are protected by interlocking derails or gates at grade crossings with interurban or other heavy or high-speed railroad systems the trolley contact conductors shall either be arranged with live trolley guards of suitable construction or shall be at the same elevation above their own tracks throughout the crossing and next adjoining spans, with catenary construction for crossing spans exceeding 100 feet.

(b) *Guards Under Bridges.*

Where passing under steel bridges that are not sufficiently elevated to prevent a trolley pole from making contact with the bridge in case it leaves the contact conductor, a substantial inverted trough or other guard of insulating material shall be so installed as to prevent the trolley pole from making an electrical connection between the contact conductor and the bridge structure. (See also Order 1229—e.)

(c) *Construction at Railway Crossings.*

Trolley contact conductors and feeders and their supporting structures, where crossing over railways, shall conform to the strength requirements specified for supply lines under Section 124 and Order 1260. The clearance of trolley construction supports from the rails of railways crossed over shall comply with the requirements for supply line supports under Order 1211—c.

(d) *Strength of Construction in Urban Districts Generally.*

Trolley contact conductors, feeders, and their supports, in urban districts, shall comply with the strength requirements for supply lines of equal voltage. Direct-current circuits of more than 750 volts to ground where at higher levels and crossing over, conflicting with, or higher than and having joint poles with, signal lines shall comply with the requirements of grade A. (See Order 1234—b-3 for special cases.)

Order 1257. Wire Clearances Above Railways, Roadways, and Footways.

The clear space between the lowest overhead trolley contact conductor or feeder, or guy, span, or messenger wire and the surfaces of rails, streets, highways, or alleys over which the former passes shall not be less than given in Table 3 of Order 1220—a.

Order 1258. Clearances of Contact Conductors from Other Wires at Crossings.

The clear space between the trolley-contact conductor and the lowest overhead conductor or wire crossing above shall be not less than the following at 60° F. with no wind.

	Feet
Signal lines	4
Supply lines, 0 to 750 volts	4
Supply lines, 750 to 7,500 volts	6
Supply lines, 7,500 to 50,000 volts	6
Guy, span, and messenger wires and service loops	4
If trolley-contact conductor is of more than 750 volts, no conductor shall cross at less than	6

For clearance increases see Order 1220-b.

Exception: Trolley feeders are exempt from a clearance requirement from contact conductors at the same nominal potential and of the same system.

Note: Unless the cross over conductors are beyond the reach of a trolley pole leaving the contact conductor or are suitably protected against damage from a trolley pole leaving the contact conductor, the clearance from trolley-contact conductors of less than 750 volts shall be not less than 6 feet.

SECTION 126. CROSSINGS OF SUPPLY LINES OVER RAILWAYS

Order 1260. Grades of Construction.

Overhead supply lines (or signal lines which have taken on the character of supply lines) crossing over railways shall comply with the construction requirements of Grade A, except when over spurs, branches, or other minor tracks only, in which case they shall comply with the construction requirements of Grade B. (See Order 1233 for full statement and Section 122 for Wisconsin statute on electric lines.)

Order 1261. Compliance with Other Orders.

Such overhead supply lines shall comply as to conductor sizes, materials, and sags, and as to materials, sizes, and strength of supporting structures and attachments with the requirements of Section 124 and Order 1270—c; as to separations, clearances and relative levels of conductors and wires on the line itself, with the requirements of Section 122; as to guys and their insulators, with the requirements of Orders 1212 and 1213 and in general with the requirements of Sections 120 and 123.

Order 1262. Pole Clearance to Rail.

(1) Poles or towers supporting the crossover spans of overhead supply lines over railways shall, unless physical conditions or municipal requirements prevent, have side clearance not less than 12 feet from the nearest track rail, except that at sidings a clearance not less than 7 feet is allowed. At loading sidings sufficient space shall be left for a driveway.

(2) If overhead lines of the railway are crossed over, the pole or tower structures of each line concerned in the crossover shall have clearances from the conductors of the other line as required by Orders 1221 or 1227—a, whichever applies.

Order 1263. Wire Clearances Above Rail.

(See also Order 1220—a, where the same requirements are given in tabular form.)

The clear space between the lowest overhead supply line conductor or wire and the heads of rails above which the former cross shall not be less than the following at 60° F. with no wind, where the conductor or wire has fixed supports and the span does not exceed 150 feet.

(a) *Clearances Where Men Are Permitted on Cars.*

Above track rails of steam railways.

(1) Supply lines of less than 300 volts to ground, overhead ground wires, and their guy, messenger, and span wires, 27 feet.

Exception: This may be reduced to 25 feet where lines are paralleled by trolley contact conductors on same street or highway.

(2) Supply lines, 300 volts to ground up to 15,000 volts, 28 feet.

Exception: This may be reduced to 25 feet where lines are paralleled by trolley contact conductors on same street or highway.

(3) Supply lines, 15,000 to 50,000 volts, 30 feet.

Exception: For conductors above 50,000 volts the given clearance shall be increased at the rate of 0.5 inch per 1000 volts excess.

(4) Trolley Contact Conductors, 22 feet.

(See also Order 1256.)

(b) *Increased Clearance for (a).*

The clearances of (a) apply to spans not exceeding 150 feet. For longer spans they shall be increased by 1 inch for each 10 feet of the excess between 150 and 300 feet and by 1 inch for each 20 feet of the excess beyond 300 feet.

Order 1264. Crossover Wire Clearances to Railway Wires.

(See also Order 1220—c, where the same requirements are given in tabular form.)

The clear space between the lowest overhead supply line conductor or guy or span wire and the highest conductor or wire crossed over concerned in the operation of the raliway (except for crossings between conductors and guy or span wires on the same poles, for which see Order 1221) shall not be less than given below, at 60° F, with no wind, where the upper conductor or wire has fixed supports (pin or strain-type insulators), and the sum of the distances from the point of intersection to the nearest supporting structure of each span, does not exceed 100 feet. (When crossing over supply conductors of the railway in excess of 7500 volts, the clearances of Order 1220—c apply.)

(1) Above signal conductors (of railways):

	Feet
Supply lines 0 to 750 volts	4
This may be reduced to 2 feet if the crossing is not within 6 feet of any pole concerned in the crossing and the voltage is not more than 300 volts.	
Supply lines, 750 to 7,500 volts	4
Supply lines, 7,500 to 50,000 volts	6
Service supply connections (0 to 750 volts)	2
Guy, messenger, and span wires	2

(2) Above supply conductors of not more than 7500 volts. (Signal conductors are defined as supply conductors when operating at more than 400 volts to ground and supplying railway signal systems.)

	Feet
Supply lines, 0 to 750 volts	2
Supply lines, 750 to 7,500 volts	2
Supply lines, 7,500 to 50,000 volts	4
Guy, messenger, and span wires*	4

*May be reduced to 2 feet when voltages do not exceed 750 volts.

Order 1265. Increase of Clearances in Special Cases.

(a) *Clearance Increase for Long Spans.*

The clearances of Order 1264 shall be increased where the sum of the distances from the point of intersection to the nearest supporting structure of each span exceeds 100 feet by 2 inches for each 10 feet of the excess between 100 and 200 feet, and by 2 inches for each 20 feet of the excess beyond 200 feet.

(b) *Clearance Increase for High Voltage.*

The clearances of Order 1264 shall be increased, where the supply line voltage exceeds 50,000 volts, by 0.5 inch per 1000 volts of the excess.

(c) *Clearance Increase for Suspension Insulators.*

The initial clearances, where the upper line at a Grade A or B crossing over track rails or signal lines is supported by suspension insulators, shall be sufficient to prevent the minimum clearances of Orders 1263 and 1264 from being reduced through the breaking of a conductor in either adjoining span by more than 10 per cent over rails or by more than 25 per cent over conductors or wires.

Note: The arrangement of insulators so that they are restrained from displacement toward the crossing will obviate necessity of any increase over the clearances given in Orders 1263 and 1264.

(d) *Increases Cumulative.*

The above increases are cumulative when more than one applies.

Order 1266. Protection Against Conductor Breakage.

(a) *Splices and Taps.*

Splices shall not be made in the crossing span and preferably not in the adjacent spans, which are depended upon for withstanding the longitudinal stress of the crossing conductors. 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.

Note: It is not the intent of this order to prohibit the installation, in either the crossing or adjacent spans, of reliable protective devices of the drop-out disconnector type that require making a joint in the conductor.

(b) *Falling Trees.*

The crossing span and the next adjoining spans shall as far as practicable be kept free from overhanging or decayed trees which might fall into the line. (See also Orders 1207 and 1211.)

Order 1267. Special Short Span Crossing Construction.

In cases where the crossover span is constructed of such height and so arranged that, in the event of breakage, no part of any conductor concerned in the crossing can come within 15 feet of the ground or of the rails, the requirements specified in Section 124 as to conductor sags and sizes are, so far as they are required by reason of the railroad crossing, waived provided that a permanently grounded guard arm is installed at each crossover support in such a manner as to prevent conductors which break in either adjacent span, from swinging back into the space between the crossover supports.

Order 1268. Underground Lines Crossing Under Railways.

Underground supply lines crossing railways shall comply with the requirements of Sections 120 and 129, and particularly of Orders 1290 and 1295. These orders require that manholes, pull boxes, and terminals shall, where practicable, be located away from the roadbed, and that conductors and cables carried underground, under railways, shall be placed in suitable ducts.

SECTION 127. SUPPLY LINES OVER SIGNAL LINES AND JOINT USE OF POLES

Order 1270. Special Requirements and Compliance with Other Orders.

(a) *Grade of Construction.*

Overhead supply lines crossing over signal lines under the circumstances noted in Order 1234 shall comply with grades of construction A, B or C, as noted in the order referred to.

(b) *Compliance with Other Orders.*

Such overhead supply lines shall comply as to conductor sizes, materials, and sags and as to materials, sizes and strength of supporting structures and attachments with Section 124; as to separations and clearances of conductors and wires of the supply line itself with the requirements of Section 122; and as to guys and their insulators with the requirements of Orders 1212 and 1213.

(c) *Where Concerned with Other Overhead Lines or With Railways.*

Such overhead supply lines where also concerned at the crossover with crossings, conflicts or common use of poles with overhead lines other than the signal lines crossed over, or with a railway crossing, shall comply also with the requirements of Order 1230 as to relative levels and with Orders 1231 to 1235 as to character of construction, with Orders 1281 and 1282 as to guying, span length, etc., and with other orders of this section which apply to these conditions.

(d) *Pole Clearance.*

The pole or tower structures of each line concerned in the crossover shall have clearances from the conductors of the other line, as required by Orders 1221 or 1227—a, whichever applies.

(e) *Wire Clearance Above Signal Wires.*

The clear space between the lowest overhead supply line conductor or guy, messenger, or span wire, and any signal line conductor or guy, span, or messenger wire over which it crosses (except for crossings between conductors and guy, messenger, or span wires on the same pole, for which see Order 1221) shall not be less than given below at 60° F. with no wind, where the upper conductor or wire has fixed supports (pin or strain-type insulators), and the sum of the distances from the point of intersection to the nearest supporting structure of each span does not exceed 100 feet.

(1) Above signal conductors:

	Feet
Services, 0 to 750 volts	2
Supply lines, 0 to 750 volts	4
Exception: This may be reduced to 2 feet, if the crossing is not within 6 feet from any pole concerned in the crossing, and the voltage is not over 300 volts.	
Services and supply lines, 750 to 7,500 volts	4
Services and supply lines, 7,500 to 50,000 volts	6
Guy, messenger, and span wires	2

(2) Above guy, span, or messenger wires (of signal lines):

	Feet
Supply lines, 0 to 750 volts	2
Supply lines, 750 to 50,000 volts	4
Guy, messenger, and span wires	2

(f) *Clearance Increases.*

The increase of clearances for longer spans, higher voltages, and for suspension insulators, shall be as given in Order 1220—d.

(g) *Special Requirements.*

Special longitudinal strength requirements are given in Order 1249.

Note: Requirements for protection against conductor breakage are given in Order 1266.

Order 1271. Supply Lines Conflicting with Signal Lines.

(a) *Strength of Construction.*

Where supply lines are at higher levels and conflict with signal lines, the requirements of Order 1270 apply in general to the conflicting supply lines, just as they apply where the supply lines cross over the same signal lines.

(b) *Avoidance of Conflict.*

Two parallel pole lines, either of which carries supply lines, shall, where practicable, be so separated from each other that neither conflicts with the other. (See Order 1272—a.)

Order 1272. The Joint Use of Poles by Signal and Supply Lines—Supply Lines Above Signal Lines.

(a) *Avoidance of Conflict by Joint Use.*

The separation of two parallel pole lines, one of which carries supply conductors and the other signal conductors shall, where practicable, be sufficient so that neither conflicts with the other, and if within conflicting distance, they shall be separated as far as practicable.

Note: (1) If separation beyond conflicting distance is impracticable the choice between a joint pole line and separate conflicting lines depends on the voltage of the supply circuits, the total number and weight of conductors, the tree conditions, number and location of branches and service drops, availability of right of way, etc., as affecting the relative safety attainable at reasonable cost.

(2) Where signal lines in urban districts are concerned only with supply lines normally operating at voltages not exceeding 5000 volts between conductors (or 2900 volts to neutral or ground) or constant-current circuits not exceeding 7.5 amperes, joint construction is recommended in preference to separate pole lines on the same street or highway unless the number of conductors is very large or the character of the circuits makes joint use undesirable.

(3) Outside corporate limits of cities or villages or districts having the same character or density of population supply lines and signal lines (unless in cable) should where practicable occupy opposite sides of the highway.

(4) Where signal lines are concerned with supply lines normally operating at more than 5000 volts between conductors (or 2900 volts to neutral or ground) or with constant current circuits carrying more than 7.5 amperes, joint use is not recommended in preference to separate pole lines, except

(I) Where it is impracticable to separate the lines sufficiently to avoid a conflict, or

(II) Where there would be a considerable number of service drops or branches from one line which must cross the other.

(5) In any event, however, joint use is preferable to the overbuilding of one pole line by another.

(b) *Strength of Poles.*

Poles used jointly by supply lines and signal lines with the supply lines above shall have the highest grade of construction specified in Order 1234 according to the voltage and character of the various lines carried by the pole.

Exception: Where the signal lines are used exclusively in the operation of supply lines the grade of construction need not be that required above, but the lines shall occupy the same relative positions noted under (f) below.

(c) *Conductor Supports.*

The strength of crossarms, pins, and fastenings shall conform to the highest grade of construction required for the lines carried by the particular crossarm concerned, according to Order 1234. This may sometimes be a lower grade than that required for the pole or tower by reason of other lines carried on higher crossarms.

(d) *Special Provision Regarding Transverse Strength.*

In calculating the transverse forces upon poles carrying supply conductors above signal conductors, where no supply conductors are below signal conductors, and where the reduction in transverse moment given in Order 1244—c is not used, the number of signal conductors upon which the transverse force is cal-

culated shall be taken as only one-half their total number, provided that they are smaller than No. 8 Stl. W. G. if steel, or No. 6 A. W. G. if copper.

Note: There are two reasons for this exception.

(1) Signal conductors of small sizes and strung to small sags are more liable to break and relieve transverse load than are larger supply conductors so strung;

(2) Joint use of poles will be encouraged and thus hazards be avoided which would exist were two separate and frequently conflicting pole lines used to limit the number of wires per pole lead.

(e) *Longitudinal Stresses.*

In calculating the longitudinal stresses upon jointly used poles complying with Grade A or B construction requirements where crossing over railways or over signal lines (where these crossings would of themselves require compliance with Grade A or B construction of the crossover span) the tension in the signal conductors shall 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 signal conductors at 60° F.

(f) *Clearances, Separations, and Relative Levels.*

The clearances and separations of supply and signal conductors on jointly used poles, as well as the relative levels are covered in detail in Orders 1224 and 1230. In general, signal lines for public use shall be not less than 4 feet below supply lines.

Exception: Span wires or brackets for supporting lamps or trolley contact wires on jointly used poles may have less clearance from signal attachments than specified in the foregoing, but in no case shall the clearance be reduced below the following:

From span wires or brackets for lamps or trolley contact wires to crossarms carrying signal conductors, 2 feet; to messenger wire carrying signal cable, 1 foot; to terminal boxes of signal cable, 1 foot.

Where it is not practicable to obtain a clearance of one foot to terminal boxes of signal cable, all metal parts of terminals shall have the greatest practicable separation from fixtures or span wires, including all supporting screws and bolts of both classes of attachments.

Note: (1) Where signal lines are below supply lines, the requirements for Grade A, B, or C, strength of the signal line crossarms, pins, and fastenings are avoided.

(2) The establishment of standardized levels in any given community, as recommended by Order 1230, facilitates the extension of lines and the safety of the public and workers by permitting the desired relative levels and clearances to be readily obtained on jointly used poles as well as in crossings and conflicts.

Order 1273. The Joint Use of Poles by Signal and Supply Lines—Signal Lines Above Supply Lines.

Note: This relation of levels is not in general desirable, and should be avoided where practicable.

(a) *Strength Requirements.*

Poles or towers used jointly by signal and supply lines, with the signal lines above the supply lines, shall comply with the requirements and rules referred to in Order 1272 as well as those in this order.

(b) *No Reduction.*

The grade of construction A or B where required for the signal lines, includes the size, material, and sag of conductors as well as the strength of structures required for supply lines of the same grade by Section 124 with no reduction in transverse strength requirements such as is permitted by Order 1272—d where supply lines are above signal lines.

(c) *Grade C Signal Conductors.*

Signal conductors which are required to comply with Grade C construction may be smaller than Grade C supply conductors, but must not be smaller nor have less sags than for Grade D construction for spans up to 150 feet; for spans over 150 feet the requirements for supply conductors must be met. (See tables for Grade D conductor sizes and sags under Order 1283.)

(d) *Minor Extensions.*

In localities where the practice of placing conductors of signal circuits for public use above supply conductors has been generally established, minor extensions with the conductors in the same relative positions and with the clearances covered by the table may be made in either system, but these extensions shall not continue beyond a location at which it becomes practicable to change to the arrangement standardized by these orders.

Order 1274. The Joint Use of Poles by Cabled Supply Lines and Signal Lines.

(a) *Requirements When Cable is Unsheathed.*

Poles used jointly by signal lines and cabled supply lines not having permanently grounded continuous metal sheath or armor shall meet all the requirements for poles used jointly by open supply and signal lines given in Order 1272.

(b) *Strength of Poles When Cable is Sheathed.*

Cabled supply lines having permanently grounded continuous metal sheath or armor shall be installed in compliance with (c), (d), (e), and (f) below. When the voltage of the cabled supply lines is greater than 750, the poles shall meet the strength requirements of Grade C as given in Section 124.

(c) *Messengers.*

Messengers shall be stranded and of galvanized or copper covered steel with strengths and sags as specified in Order 1283—f or if of other sizes shall not be stressed beyond half their ultimate strength when the cable and messenger are coated with one-half inch of ice and subjected to a transverse wind pressure of 8 pounds per square foot of projected area.

(d) *Grounding of Cable Sheath.*

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 eight hundred feet apart. (See Introductory Part for method.)

(e) *Splices.*

Splices in the cable shall be so made 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.

(f) *Insulation.*

The conductors of the cable shall be so insulated 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.

Order 1275. Special Crossing Construction.

(a) *Short Spans.*

In cases where the crossover span is constructed of such a height that its length is less than the distance between either point of support of its lowest conductor and the highest conductor of the line crossed, the requirements for conductor sags and for size and type of conductors in Section 124 are waived, provided that a permanently grounded guard-arm is installed at each crossover support in such a manner as to prevent conductors, which break in either adjacent span, from swinging back into the conductors of the span crossed over.

Note: This character of construction is facilitated where the span crossed over is at a minimum elevation above ground level, and where the crossover supports can be placed quite near together.

(b) *Cradles.*

Cradles are not recommended. 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.

SECTION 128. STRENGTH AND OTHER REQUIREMENTS FOR SIGNAL LINES AT CROSSINGS AND ALONE

Order 1280. General Requirements.

(a) *Conditions Determining Grade.*

(1) Signal lines crossing over railways, except in the cases mentioned in Order 1235—b, c, d and e, are classed as Grade D and shall have construction in accordance with the following requirements. Signal lines crossing over minor tracks (as described in Order 1235—b) shall conform to the requirements for Grade E.

(2) Where also crossing over supply lines (or signal lines having the character of supply lines) in the same span, the construction required shall comply either with Grade D, Grade E, or with Grade A or B according to the voltage of the supply line (see Section 123.)

(3) Signal lines crossing over the supply lines covered in Order 1234—c, and also crossing over railways in the same span, shall comply with Grade D or E requirements except that Grade C requirements apply to conductor sizes and sags for spans exceeding 150 feet. (See also Section 122 for Wisconsin statute on electric lines.)

Note: The requirements for signal lines crossing over or conflicting with supply lines only are specified in Order 1287, and for signal lines crossing over trolley contact conductors in Order 1286.

(b) *Transverse and Longitudinal Strength.*

The paragraphs which specify the transverse and longitudinal requirements relate to Grade D construction unless otherwise stated. For Grade E the transverse and longitudinal strength shall be not less than two-thirds of that required for Grade D.

(c) *Preliminary Assumption.*

In the calculation of all stresses no allowance shall be made for deformation, deflection, or displacement of any part of the supporting structures.

(d) *Inspection.*

All parts of the supporting structures of the crossing span shall be examined periodically by the owner and all defective parts shall be promptly restored to a safe condition.

Order 1281. Transverse and Longitudinal Strength.

(a) *Transverse Guying.*

(1) The poles supporting the crossing span shall be side guyed or braced to withstand the transverse load put upon them in accordance with the conditions specified below. The guys shall be considered as taking, in the direction in which they act, the horizontal component of the entire load, the poles, acting as struts, resisting the vertical component. The calculated stresses in the guys shall not exceed one-half the ultimate strength of the material.

(2) The assumed horizontal wind pressure at right angles to the direction of the line upon the poles and conductors shall be taken as 8 pounds per square foot of projected area on cylindrical surfaces. The pressure shall be computed upon the poles without ice covering, while the conductors shall be assumed to be covered with a layer of ice one-half inch in radial thickness. In computing the transverse pressure on conductors the actual number of conductors shall be used up to 10. For larger numbers of wires only two-thirds of the total number shall be counted with a minimum of 10.

(3) In calculating transverse load a cable with its supporting messenger with the ice covering shall be figured at their full value. (See exceptions below.)

(b) *Longitudinal Guying.*

(1) The poles supporting the crossing span shall be head guyed away from the crossing so as to withstand the load specified below. The guys shall be considered as taking, in the direction in which they act, the horizontal component of the entire load, the poles, acting as struts, resisting the vertical component. The calculated stresses in the guys shall not exceed the ultimate strength of the material.

(2) The longitudinal load shall be assumed equivalent to an unbalanced pull in the direction of the crossing of all conductors or wires supported, the pull of each conductor or wire being taken as one-half its ultimate strength. In any case where the total pull exceeds 10,000 pounds the load shall be taken as 10,000 pounds plus one-quarter of the excess above 10,000 pounds.

(3) For head guying, cables are not included in the count of wires since the messenger serves as a head guy.

Exception to Order 1281—a and b: (1) If a pole is of such strength that it will not be stressed by the specified transverse loading beyond one-fourth its ultimate strength when installed, side guys may be omitted. If the specified longitudinal loading on such a pole will not stress it initially beyond one-half its ultimate strength and there are not more than two wires in the crossing span, head guys may also be omitted.

(2) Where an overhead crossing which makes an angle with the tracks of less than 45 degrees involves at either crossing pole an angle in the pole line, the side guy within the angle may be omitted.

(3) Where a signal line paralleling a railroad track on the right of way of the railroad crosses a spur or stub-track without any change in 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, and no requirements for longitudinal strength are made if 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, guys or braces shall be installed capable of withstanding such unbalanced tensions.

(4) Where on account of physical conditions it is impracticable to guy or brace the crossing poles as specified above, 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 cable 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 cable being securely attached to every pole between the guyed poles.

Note: Where the poles supporting the crossing span are not in line with the poles in the adjoining spans, additional guying shall be placed to take care of the increased stress.

Order 1282. Relation of Crossing Span to Line.

(a) *Span Length.*

(1) Poles shall, where practicable, be so located that crossing and adjacent spans are in a straight line and free from exposure to overhanging or closely adjacent trees or inflammable material

or structures. (See also Order 1211 for requirements as to location of poles.)

(2) 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.

(b) *Grading or Vertical Displacement of Crossing Span.*

The vertical distance from the top crossarm of a crossing pole to a straight line connecting the top crossarms of the next adjacent poles on either side of this crossing pole, shall not exceed the values given in the following table:

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

Order 1283. Minimum Sizes and Construction Details.

(a) *Size of Pole and Setting.*

Wood poles supporting the crossing span shall be of selected timber, sound and reasonably straight. Poles shall have dimensions not smaller than the values given in the tables of Appendix B when carrying the numbers of wires there designated.

(1) Grade D. The minimum dimensions given in the tables of Appendix B correspond to poles designated by the wire-owning companies as class C, where not more than 20 wires are carried; class B, where 21 to 40 wires are carried; class A, where more than 40 wires are carried.

(2) Grade E. The minimum dimensions given in the tables of Appendix B correspond to poles designated by the wire owning companies as Class C where not more than 40 wires are carried; class B where more than 40 wires are carried.

(b) *Crossarms.*

(1) Wood crossarms supporting the crossing span shall be of yellow pine, fir, or other suitable timber and shall have a minimum section of 2¾ by 3¾ inches. Galvanized or painted iron or steel crossarms of equal strength may be used.

(2) Crossarms and insulators shall be double on the crossing poles. The crossarms shall be held together with properly fitted spacing blocks or bolts placed immediately adjoining the outside pins and shall not support more than 10 conductors.

(c) *Pins, Insulators and Tie Wires.*

(1) Insulator pins shall be of steel, wrought iron, malleable cast iron, or locust or equivalent wood. Steel or iron pins shall have a shank diameter not less than ½ inch. Wood pins shall be sound and straight grained with a diameter of shank not less than 1¼ inches. Insulator pins shall have strength sufficient to withstand the loads to which they may be subjected.

(2) 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. The conductors shall be securely tied to each supporting insulator.

(d) *Conductors.*

(1) 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) If spans in excess of 150 feet are necessary, the size of conductors specified or the sags shall be correspondingly increased. (See Order 1282—a.)

(3) 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 below.

(4) Twisted pair wires without a supporting messenger shall in no case be used for Grade D in spans longer than 100 feet, nor for Grade E in spans longer than 125 feet, and shall be eliminated as far as practicable. Each wire of a twisted-pair not supported by a messenger shall be tinned hard-drawn copper not smaller than No. 14, or tinned copper-covered steel not smaller than No. 17 or equivalent.

(5) The minimum allowable sizes for conductors of the crossing span shall be as follows:

TABLE 11.—(1) MINIMUM WIRE SIZES FOR GRADE D

Conductor	Spans 125 Feet or Less	Spans Over 125 Feet and Not Over 150 Feet
Hard drawn copper	No. 10 A. W. G.	No. 9 A. W. G.
Galvanized steel	No. 10 Stl. W. G.	No. 8 Stl. W. G.
Galvanized steel in rural districts	No. 12 Stl. W. G.	No. 10 Stl. W. G.

Note: The use of No. 12, and No. 10 steel wire is not recommended over railroads where train service is frequent or wire is subject to excessive corrosion.

TABLE 12.—(2) MINIMUM WIRE SIZES FOR GRADE E

Conductor	Spans 125 Feet or Less	Spans Over 125 Feet and Not Over 150 Feet
Hard drawn copper	No. 10 A. W. G.	No. 10 A. W. G.
Galvanized steel	No. 12 Stl. W. G.	No. 10 Stl. W. G.

(3) MINIMUM WIRE SIZES FOR GRADE C

Signal conductors which are required to comply with grade C construction may be smaller than grade C supply conductors, but shall not be smaller nor have less sags than for grade D construction for spans up to 150 feet; for spans over 150 feet the requirements for supply conductors shall be met.

Conductors of the crossing span shall be strung with sags not less than shown in the following table:

TABLE 13.—SAGS OF HARD-DRAWN BARE COPPER WIRE OR STEEL

Length of Span in Feet	Sag in Inches		
	At 20° F.	At 60° F.	At 100° F.
80	2.5	4.5	8.5
90	3.5	5.5	10
100	4.5	7	12
110	5.5	8.5	14
120	6.5	10	16
130	7.5	12	19
140	9.5	15	22
150	11.5	18	25

(e) *Guys.*

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. The guys shall be attached as near to the center of the load as practicable. The guys and anchors shall be maintained so that the guys are kept taut and serve the purpose for which they are intended.

(f) *Messengers.*

(1) The following table gives the minimum sizes of galvanized steel strand messenger cable to be used for supporting different sizes of conductor cable:

TABLE 14.—MINIMUM SIZES OF MESSENGER CABLE

Size of Conductor Cable in Weight per Foot	Messenger Cable (Nominal) Ultimate Tensile Strength
Less than 2.25 pounds	6,000 pounds
2.25 to 5 pounds	10,000 pounds
Exceeding 5 and less than 8 pounds	16,000 pounds

(2) For spans exceeding 150 feet or for heavier cables a proportionately larger messenger cable or other proportionately stronger means of support shall be used.

(3) Multiple wire cables and their messengers shall be suspended with a normal sag of 60° F. so that when they are subject to the loading prescribed in Order 1281 the tension in the messenger cable will not exceed the following values:

Nominal Ultimate Tensile Strength of Messenger Cable	Safe Working Tension of Messenger Cable
6,000 pounds	3,500 pounds
10,000 pounds	5,900 pounds
16,000 pounds	9,500 pounds

Order 1284. Signal Line Clearances.

(a) *Clearances from Ground or Rails.*

(1) The clear space between the lowest signal conductor, guy or messenger and the heads of rails shall, at 60° F. with no wind, be in general not less than 27 feet.

(2) When the signal conductors are paralleled on the same highway by a trolley contact conductor at a lower level, the clearance of the signal conductors from the rail may be reduced to 25 feet.

(3) When signal conductors cross tracks not carrying traffic which involve brakemen riding on top of standard freight cars, the above clearance may be reduced to 25 feet for steam railroad tracks and 18 feet for other tracks.

(4) When spans exceed 150 feet in length, additional clearance must be provided as given by Order 1220—b.

(b) *Clearances from Other Wires.*

(1) The clear space between the lowest signal conductor, guy or messenger and the highest wire of a similar nature paralleling the track, shall be not less than two feet where the sum of the distances from the point of intersection to the nearer supporting structure of each span is 100 feet or less. Where the sum of these distances exceeds 100 feet and for crossings over supply wires, the requirements of Order 1220—c and d must be met.

(2) 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.

Note: This should preferably be 24 inches. (See also Order 1223.)

(c) *Pole Clearances.*

Unless physical conditions or municipal requirements prevent, the side clearances of poles shall be not less than 12 feet from the nearest track rail, except at sidings where clearance of not less than 7 feet is allowed. Where conductors of one pole line cross over or under conductors of a second line there shall, if practicable, be not less than 3 feet clearance between the conductors of the first line and any pole or tower of the second line, unless the conductors are attached thereto.

Order 1285. Crossings of Signal Lines Beneath Railways.

(a) *Underground.*

Underground signal lines crossing railways shall conform to the requirements of Sections 120 and 129 and particularly of Orders 1290 and 1295. Manholes, pull boxes and terminals shall be located away from the road bed (preferably outside the fenced right of way of the railway). Conductors and cables carried underground under railways shall be placed in suitable ducts conforming to the requirements of Section 129.

(b) *Under Bridges.*

Overhead signal lines passing beneath bridges over which railways pass shall conform to the general requirements of Section 120, to the requirements for grade of construction of Section 123, to the requirements for conductor clearances and separations of Section 122, and to the special requirements for supports and wiring arrangements of Section 121.

Order 1286. Signal Lines Crossing Over Trolley Contact Conductors (Where Grade D or E Is Not Required).

(a) *When Crossing Trolley Contact Conductors Not Exceeding 750 Volts.*

(1) Signal lines, except twisted-pair conductors and fire alarm conductors (for which see Orders 1283—d and 1288—b), carried over trolley-contact conductors of not more than 750 volts shall have conductor sizes not less than the following:

No. 12 hard-drawn copper or steel in spans less than 100 feet.

No. 10 in spans of 100 to 125 feet.

No. 9 in spans up to 150 feet.

(2) Sags shall not be less than those given in Table 13 for Grade D. For spans longer than 150 feet the requirements of Order 1246 for conductor sizes and of Appendix A for sags of Grade C supply lines shall be complied with.

(3) Twisted pair conductors, unsupported by messengers, shall not be used in spans over 100 feet, if carried over trolley contact conductors unless each wire is hard-drawn copper not less than No. 14 or tinned copper covered steel not less than No. 17, or its equivalent.

(4) The clearance of signal lines above contact conductors crossed over shall be in accordance with the values given in the tables of Order 1220—c and d.

(b) *When Crossing Trolley Contact Conductors Exceeding 750 Volts.*

(1) For signal lines carried over trolley contact conductors of more than 750 volts to ground see Order 1234.

(2) Twisted pair conductors may be used under the restrictions given in (a) above, but if in A or B construction, they shall have sags not less than those required by Appendix A for No. 8 hard-drawn copper, and where supported by a messenger, the messenger shall have the sags required, in Order 1283—f. Where supply line voltage exceeds 7500 volts the twisted pair shall always be supported by a messenger.

(3) The clearances of signal lines above the contact conductors crossed over shall be in accordance with the values given in the table of Order 1220—c.

Order 1287. Signal Lines Crossing Over or Conflicting with Supply Lines of More Than 750 Volts.

Note: This construction is not recommended except over trolley feeders.

(a) *Strength of Construction.*

Overhead signal lines crossing over supply lines under the circumstances noted in Order 1234 shall comply with the construction requirements of Grade A, B, or C, as required in that order. (See Order 1289 for signal lines used in the operation of supply lines.)

(b) *Compliance with Other Orders.*

Where signal lines crossing over supply lines are required to comply with Grade A, B, or C construction, they shall comply as to conductor sizes, materials, and sags, and as to materials and

strength of supporting structures and attachments with Section 124; as to separation and clearances of conductors and wires of the signal lines themselves with the requirements of Section 122; as to guys and their insulators with the requirements of Orders 1212 and 1213, and in general with the requirements of Sections 120 and 121.

(c) *Where Concerned Also with Railways.*

Where the signal lines referred to in (a) above are required to comply with Grade C construction and also cross over railways under circumstances calling for compliance with Grade D or E construction, Grade D or E shall be met in all respects except as to conductor sizes and sags, which shall comply with Grade C. For spans up to 150 feet these are the same as for Grade D, Order 1283—d. For spans over 150 feet see Order 1246—b and Appendix A.

(d) *Pole Clearance.*

The pole or tower structures of each line concerned in the crossover shall have clearance from the conductors of the other line as required by Order 1221 or 1227, whichever applies.

(e) *Wire Clearance Above Supply Lines.*

The clear space between the lowest overhead signal line conductor (or guy, messenger, or span wire) and any supply line conductor or guy, span, or messenger wire which it crosses over shall not be less than given below, at 60° F. with no wind, where the upper conductor or wire has fixed supports and the sum of the distances from the point of intersection to the nearest supporting structure of each span does not exceed 100 feet:

	Feet
Signal Lines	
Above supply conductors of less than 7,500 volts	4
Above supply conductors 7,500 to 50,000 volts	6
Above supply service conductors (not exceeding 750 volts)	2
Above supply guy, messenger and span wires	2
Guy, Span and Messenger Wires.	
Above supply conductors of less than 750 volts	2
Above supply conductors 750 to 7,500 volts	4
Above supply conductors 7,500 to 50,000 volts	4
Exception: For crossings between conductors and guy, messenger or span wires on the same pole, see order 1221.	

(f) *Clearance Increases.*

Clearance increases for long spans and high voltages are given in Order 1220—d.

(g) *Falling Trees.*

The crossing span and the next adjoining spans, shall as far as practicable be kept free from overhanging or decayed trees, which might fall into the line. (See also Order 1207.)

(h) *Special Longitudinal Requirements.*

For special requirements for longitudinal strength of crossover supports of signal lines crossing over supply lines, where compliance with Grade A or B is required for signal lines, see Order 1249.

(i) *Special Short Span Crossovers.*

For special short span crossing construction, see Order 1275.

(j) *Guys.*

Guys may be used to meet the strength requirements of Section 124 and where used they and their insulators and guards shall conform to Orders 1212 and 1213.

(k) *Signal Lines Conflicting with Supply Lines.*

Where signal lines are at higher levels and conflict with supply lines the requirements of (a) and (b) above apply in general to the conflicting signal lines just as they apply where the signal lines cross over the same supply lines.

Note: Clearances from the poles and conductors of a second line are given in Order 1227.

Requirements for guys are given in Order 1212.

Order 1288. Signal Lines Alone (or Concerned Only with Other Signal Lines).

(a) *Conductors for Fire Alarm Lines.*

Conductors used for fire alarm circuits shall comply with the requirements of Order 1283—d for Grade D for sizes and sags in spans up to 150 feet. For spans over 150 feet they shall have Grade C sizes as given in Order 1246—b and sags not smaller than listed for Grade C in Appendix A.

Exception: Where carried at higher levels than supply conductors in crossings, conflicts, or common use of poles, they shall comply with grades A, B or C construction requirements according to Order 1234.

(b) *Conductors for Other Signal Lines.*

Conductors for signal lines other than fire-alarm lines unless crossing over railroads or crossing at higher levels or conflicting with, or on the same poles above supply (or trolley) lines, need not

comply with any requirements as to size, material, or sag. (See Order 1201.)

(c) *Supporting Structures for Signal Lines.*

(1) The poles used for all signal lines, unless crossing over railways or exposed to supply (or trolley) lines by crossing above, conflicting with, or being carried above the supply lines on the same poles, need not comply with any requirements as to strength and material except that poles and crossarms shall be of such initial size, and so guyed or braced where necessary as to safely withstand the vertical loads to which they may be subjected, including linemen working on them.

(2) In other respects all signal line supports shall comply with the general requirements of Sections 120 and 121 covering traffic guards, pole clearances, guys and other matters.

(d) *Clearances Above Ground* (see also Order 1220—a and b).

(1) Signal conductors alone and their guys, span wires, and messengers shall have clearances above streets, highways, alleys or generally accessible spaces across or along (and above) which the former pass, not less than the following at 60° F. with no wind, when the spans do not exceed 150 feet:

SIGNAL LINES, OR GUY, SPAN OR MESSENGER WIRES	Feet
Crossing streets and highways	24
Along roads in rural districts	14
Crossings above spaces or ways accessible only to pedestrians and above roadways to residence garages	10

Exception: The clearances do not apply to guys not carried over roadways, or to guys along one side of a street or alley, unless over driveways. For guys on private right of way, or parallel to sidewalk curbs, when not passing over pathways, or roadways, no clearance is required; and if passing over only pathways the clearance may be reduced to 8 feet.

(2) For signal-line spans over 150 feet these clearances shall be increased at the rate of one inch for each 10 feet excess.

(e) *Clearances from Other Signal Lines* (see also Order 1220—c and d).

Signal conductors and their guy, span, or messenger lines concerned in crossings, conflicts, or common use of poles with other signal lines only, shall have a minimum of 2 feet clearance from those of other lines.

Exception: Except for fire-alarm lines this may be reduced where desired, unless one set of conductors is for public use and the other is used in the operation of supply lines.

(f) *Grounding, Isolation, or Protection.*

(1) Signal lines, including fire-alarm lines, if at any point in their course exposed to supply (or trolley) lines of more than 400 volts to ground, shall be protected at each station for public use by one of the methods specified in Part 3, Section 139. These lines shall elsewhere be isolated by elevation or otherwise guarded so as to be inaccessible to the public.

(2) Signal lines used in the operation of supply lines shall be at all points isolated by elevation or otherwise guarded so as to be inaccessible to the public.

(3) Metal sheathed cables and messengers shall be isolated or grounded in conformity with the general requirements of Section 120.

Order 1289. Signal Lines Used Exclusively in the Operation of Supply Lines.

(a) *Under Other Lines.*

Such signal lines when

(1) Crossed over by, or

(2) Having conflicting with them, or

(3) On common poles and below high voltage direct current trolley circuits or other supply lines in the operation of which they are used, may be considered and run as ordinary signal lines, If

(1) These signal lines do not cross over or conflict with, and are not on common poles with, and higher than other lines or equipment and

(2) The signal lines and connected equipment are adequately guarded and accessible only to authorized persons and

(3) The precautions of Section 139 have been taken.

Exception: The supply lines concerned above are not required by the conditions described to comply with the requirements of Sections 125 and 127 as to strength of construction, but the conductors shall be not smaller than permitted by Order 1246—b.

(b) *Over Other Lines.*

Such signal lines, if crossing over, conflicting with or higher on common poles with other lines or equipment shall comply with all

the requirements for the highest voltage supply lines of not more than 7500 volts with which the signal lines may come in contact, except as to wire sizes for Grade C for which see Order 1283—d. If, however, the signal lines are protected by fuseless lightning arresters, drainage coils, or other suitable protective devices to prevent the signal line voltage from normally exceeding 400 volts to ground, they may be run as ordinary signal lines. The method used shall be consistently adhered to throughout the extent of the entire system.

SECTION 129. UNDERGROUND LINES—MANHOLES, HANDHOLES, SPLICING CHAMBERS AND DUCTS, CONDUCTORS AND EQUIPMENT

Order 1290. Location and Accessibility of Conduits and Manholes.

(a) *General Locations.*

Underground systems of electrical conductors shall be so located as to be subject to the least practicable amount of disturbance.

Note: When being designed and installed, care should be exercised to avoid catch basins, street railway tracks, gas pipes, or other underground structures.

(b) *Ducts.*

To facilitate installing and withdrawing cables and conductors, the ducts between adjacent manholes or other outlets shall in general be installed in straight lines. When it is necessary to install curves, they shall be of the greatest practicable radius, and the spacing between adjacent manholes shall be correspondingly reduced.

(c) *Manholes.*

Manholes shall, where practicable, be so located as to provide convenient access and, if possible, so that the least horizontal distance from any rail of a railroad track to the nearest edge of a manhole opening is not less than 3 feet.

Order 1291. Grading of Ducts.

Manholes or handholes shall when practicable be so located and ducts so graded that drainage of ducts will always be toward manholes or handholes. To insure satisfactory drainage, the

ducts shall be so installed as to provide, where practicable, a grade of not less than 3 inches in 100 feet of length.

Order 1292. Mechanical Details of Manholes.

(a) *Minimum Strength.*

The mechanical design and construction of manholes and handholes shall be such as to provide sufficient strength to safely sustain with a suitable margin of safety the mechanical loads which reasonably may be expected to be imposed upon them.

(b) *Entrance.*

The entrance to all manholes shall be not less than 24 inches minimum diameter. Round openings are recommended.

(c) *Dimensions.*

Manholes shall be so constructed, when practicable, that the least inside horizontal dimensions will be not less than 3 feet 6 inches and shall be so arranged as to maintain, if practicable, a clear working space not less than 3 feet horizontally and 6 feet vertically.

Exception: When side walls of the manhole are within one foot of the edge of the opening the depth may be less.

(d) *Drainage and Ventilation.*

(1) Where surface or ground water is liable to enter manholes containing supply conductors, these shall be so arranged, if practicable, as to provide permanent drainage.

(2) Where drainage is into sewers, suitable traps shall be arranged to prevent entrance of sewer gas into manholes.

(3) Manholes shall have adequate ventilation to open air where any opening exists from such chambers into subways entered by the public, as with some subway conduit systems, or where other conditions are such as to make ventilation necessary.

Order 1293. Manhole Covers and Guards.

(a) *Covers.*

Manholes and handholes, while not being worked in, shall be securely closed by covers of sufficient strength to sustain such mechanical loads as may reasonably be expected to be imposed upon them, and the arrangement shall be such that a tool or appliance is required for their opening or removal.

(b) *Barriers or Guards.*

Manhole openings shall be so arranged that when they are uncovered barriers or other suitable guards may be placed to effectively guard the opening.

Order 1294. Material, Size, and Finish of Ducts.

Ducts used in underground systems of distribution for electrical supply and signal conductors shall be of such material, size, mechanical strength, and finish as to facilitate the installation and maintenance of conductors or cables.

Order 1295. Installation of Conduits.

(a) *Protection.*

Ducts shall be suitably reinforced or be laid on suitable foundations of sufficient mechanical strength where necessary to protect them from settling, and shall be protected by concrete or other covering where necessary to prevent their disturbance by workmen when digging, or by other causes.

(b) *Smooth Surfaces.*

Ducts shall have clear bores and be freed from burrs before laying. They shall be laid in line in such manner as to prevent inside shoulders at joints.

(c) *Termination in Manhole.*

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.

(d) *Clearances.*

(1) Duct runs shall provide as great a clearance from other underground structures as practicable, and particularly from gas lines. The distance between the top of the conduit covering and the pavement surface or other surfaces under which the duct run is constructed, shall be sufficient to protect the conduit from injury.

(2) The top of the conduit structure shall generally be located at a depth of not less than 30 inches below the base of rail of street railway tracks, nor less than 42 inches below the base of rail of steam and electric railroads. By agreement of the parties concerned, these clearances, where impracticable or for other reasons, may be reduced, but in no case shall the top of the conduit structure extend higher than the bottom of the ballast section which is subject to working and cleaning.

Note: The above clearances are based on a duct formation, the width of which is not more than three creosoted wood, four vitrified clay, or four impregnated fibre ducts, or four iron or mild steel pipes, and do not apply to bridge type structures designed to sustain the weight of the roadbed and the operating load. When a wider duct formation is contemplated, additional strength of construction and protection should be provided or the conduit placed at a greater depth.

(e) *Walls Between Supply and Signal Conduits.*

Conduits, including laterals, to be occupied by signal conductors for public use shall, where practicable, be separated from underground conduit and laterals for supply conductors by not less than 3 inches of concrete or its equivalent.

Exception: Cable extensions may, however, be made to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, signal and power companies, with less effective separations than above specified.

(f) *Supply and Signal Conduits Entering Manholes.*

Where signal conductors and supply conductors occupy ducts terminating in the same manhole, the two classes of duct shall be separated as widely as practicable, and where practicable, shall enter the manhole at opposite sides, so that cables can be racked along side walls with a minimum of crosses between the two classes of conductors. (See also Order 1296—a.)

(g) *Joints.*

Joints in duct runs shall be made mechanically secure to maintain individual ducts in alignment.

(h) *Openings Into Manholes.*

Duct openings into manholes or handholes shall, where practicable, have a clearance above the floor or below the roof line of not less than six inches and from either side wall of at least four inches.

(i) *Laterals.*

Ducts of laterals supplying service to buildings, shall be effectively plugged at the entrance of building or cemented by the use of asphaltum, pitch, or other suitable means. (See also Order 1322—b, Section 132, Part 3.)

(j) *Dissipation of Heat.*

Conduits designed to carry supply cables of large current capacity shall be arranged, where practicable, so that ducts carrying such cables will not dissipate heat solely through other ducts.

Note: Conductors of large current carrying capacity should where practicable be placed in outside ducts where they will not necessarily dissipate heat solely through adjacent ducts.

Order 1296. Location and Identification of Conductors.

(a) *Separation of Supply and Signal Systems.*

Underground systems of electrical supply conductors and of signal conductors for public use shall in general be maintained in separate conduits and particularly in separate manholes. (See also Order 1295—e.)

Exception: Cable extensions to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, signal companies, and power companies are exempted from the above.

Note: When signal conductors for public use and electrical supply conductors occupy the same manholes, they should be maintained at opposite sides of the manhole and where necessary separating barriers should be installed. Where supply cables are of large current capacity all cables should be specially protected against injury by arcing. When it is necessary that the signal and supply cables cross in any manhole, a spacing of at least 1 foot should be maintained and special mechanical protection provided against abrasion or injury by arcs.

(b) *Identification.*

Cables shall be permanently identified by tags or otherwise at each manhole, handhole, or other permanent opening of the underground system, except where their position, in conjunction with diagram supplied to workmen, gives sufficient identification.

(c) *Accessibility.*

Cables in manholes shall be reasonably accessible from the clear working space at all times. When cables cross by or over other cables, sufficient clearance shall be provided between them to permit reasonable access to any cable for inspection and repair and to prevent abrasion.

Note: Joints made in, or branches made from, underground cables should be reasonably accessible at all times and should be in manholes or handholes, and as seldom as possible in the ducts themselves.

(d) *Clearance in Manholes.*

Each cable, where practicable, shall maintain a vertical clearance above the floor of any manhole of not less than 6 inches.

Order 1297. Mechanical Protection, Support, and Guarding of Live Parts.

(a) *Cable Sheath.*

Cables, unless rubber insulated, shall be provided with a water tight metal sheath or other waterproof covering over their insulating coverings, except when used as ground connections or neutrals.

Note: Closely grouped lead covered supply cables should have suitable fire resistive coverings to prevent damage from arcing.

(b) *Guarding of Live Parts.*

(1) Protective, control, or other apparatus on supply lines where installed and maintained in manholes and handholes shall have live parts inclosed in suitable 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.

(2) Joints or terminals of conductors or cables of underground electrical supply systems shall be so arranged that there are no bare ungrounded current-carrying metal parts exposed to accidental contact within manholes or handholes.

(c) *Supports.*

Mechanical support 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 conduit line itself serves as sufficient support for the cables.

(d) *Underground Risers.*

(1) Conductors or cables from underground systems which connect to overhead systems shall be mechanically protected. Exposed metal riser pipes containing supply conductors shall be grounded unless such conductors are covered with a grounded metal sheath or are themselves grounded.

(2) Conductors or cables from underground systems which connect to overhead systems shall, if operating at more than 750 volts to ground, terminate in suitable potheads, switches, or similar devices of approved design or construction.

(3) Open supply wiring connecting to underground systems shall begin not less than 8 feet above the ground surface or platform accessible to the public.

(4) When practicable, risers to contain conductors or cables used for signal systems shall not be placed on the same pole with risers to be used for supply systems. If, however, it is necessary to use the same pole for risers of both systems, the risers for the different systems shall, in so far as practicable, be placed on opposite semi-circumferences of the pole.

Order 1298. Spacing of Cables.

(a) *Different Voltages.*

Cables shall be so arranged and supported in ducts and manholes that those of higher operating voltages are separated from those of lower voltages as far as practicable.

Note: It is recommended that the higher voltage cables be carried in the lower ducts of a conduit system. In this position they are less liable to injury from external sources and less liable to damage from serious manhole fires.

(b) *Different Systems.*

Cables belonging to different systems (particularly supply distribution and signal systems) shall not be run in the same duct.

Order 1299. Multiple Connections.

When 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: Such marking is not required when suitable cut-outs are provided on both high and low tension sides of apparatus.

APPENDICES OF PART 2

APPENDIX A. LOADING DATA, MECHANICAL CHARACTERISTICS, AND RECOMMENDED NORMAL SAGS OF OVERHEAD LINE CONDUCTORS

1. RECOMMENDED SAGS, WITH CORRESPONDING TENSIONS AND STRESSES OF COPPER LINE CONDUCTORS

While the following sags are those generally recommended, circumstances will sometimes call for modifications. For instance, where many large conductors are carried by a pole line, greater sags than those listed for the larger conductors will sometimes be advisable, to reduce the stresses on poles at turns and dead ends, and to permit smaller longitudinal guying at crossovers where such guying is called for by the orders. (See Order 1249.)

The figures given for the sags and tensions have been rounded off to the nearest value which can be readily measured by methods and instruments in practical use for this purpose.

The definition of "loaded" may be found in Order 1241.

TABLE 15—SAGS FOR HARD AND MEDIUM DRAWN BARE COPPER WIRE FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size A. W. G.	Grade of Constr.	Temp. Deg. F.	Sags — Span Lengths—Feet								
			100	125	150	175	200	250	300	400	500
			In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	C	30	8	11	22	.....	.....	.....	.....	.....	.....
		60	12	18	27	.....	.....	.....	.....	.....	.....
		90	16	22	32	.....	.....	.....	.....	.....	.....
No. 6	A	30	8	11	22	.....	.....	.....	.....	.....	.....
		60	12	18	27	.....	.....	.....	.....	.....	.....
		90	16	22	32	.....	.....	.....	.....	.....	.....
	B	30	6	10.5	16	.....	.....	.....	.....	.....	.....
		60	10	15	22	.....	.....	.....	.....	.....	.....
		90	14	19.5	27	.....	.....	.....	.....	.....	.....
	C	30	6	10.5	16	28	.....	.....	.....	.....	.....
		60	10	15	22	33	.....	.....	.....	.....	.....
		90	14	19.5	27	39	.....	.....	.....	.....	.....
No. 4	All	30	6	10.5	16	22	32	64	109	.....	.....
		60	10	15	21	28	38	71	115	.....	.....
		90	14	19.5	26.5	34	45	77	120	.....	.....
No. 2	All	30	6	10.5	13	16	18.5	35	59	129	218
		60	10	15	18	21	24	44	68	137	226
		90	14	19.5	23.5	28	31	51	75	144	234
No. 1	All	30	6	10.5	13	16	18.5	32	51	113	195
		60	10	15	18	21	24	40	59	120	203
		90	14	19.5	23.5	28	31	47	67	130	212
No. 0	All	30	6	10.5	13	16	18.5	31	45	100	170
		60	10	15	18	21	24	38	55	110	180
		90	14	19.5	23.5	28	31	46	63	120	190
No. 00	All	30	6	10.5	13	16	18.5	29	42	92	157
		60	10	15	18	21	24	36	50	102	168
		90	14	19.5	23.5	28	31	44	58	111	179
No. 0000	All	30	6	10.5	13	16	18.5	26	34	73	118
		60	10	15	18	21	24	32	42	84	132
		90	14	19.5	23.5	28	31	40	50	94	142

TABLE 16—SAGS FOR HARD AND MEDIUM DRAWN COVERED COPPER WIRE FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size A. W. G.	Grade of Constr.	Temp. Deg. F.	Sags — Span Lengths—Feet						
			100	125	150	175	200	250	300
			In.	In.	In.	In.	In.	In.	In.
No. 8	C	30	15	23	36	.....	.....	.....	.....
		60	18	27	40	.....	.....	.....	.....
		90	21.5	31	44	.....	.....	.....	.....
No. 6	A	30	15	23	36	.....	.....	.....	.....
		60	18	27	40	.....	.....	.....	.....
		90	21.5	31	45	.....	.....	.....	.....
No. 6	B	30	11	17.5	27	.....	.....	.....	.....
		60	15	22	33	.....	.....	.....	.....
		90	18	26	38	.....	.....	.....	.....
No. 6	C	30	8.5	14	22	31	.....	.....	.....
		60	12	18	27	36	.....	.....	.....
		90	15.5	22.5	32	40	.....	.....	.....
No. 4	All	30	8.5	14	21.5	31	43	.....	.....
		60	12	18	27	36	48	.....	.....
		90	17	22.5	32	41	54	.....	.....
No. 2	All	30	8.5	14	21.5	23.5	30	53	89
		60	12	18	27	30	36	60	96
		90	17	22.5	32	35	42	67	103
No. 1	All	30	8.5	13.5	21	23	27	44	72
		60	12	18	26	29	33	52	80
		90	15.5	22.5	31	34	39	59	87
No. 0	All	30	8.5	13.5	20.5	22.5	26	42	66
		60	12	18	26	28	32	49	72
		90	15.5	22.5	31	34	38	56	82
No. 00	All	30	8.5	13.5	20	22.5	25	38	57
		60	12	18	25	28	31	46	66
		90	16	22.5	30	34	38	53	73
No. 0000	All	30	8.5	13.5	18.5	21	24.5	31	43
		60	12	18	24	27	30	38	50
		90	16	22.5	29	33	36	46	59

TABLE 17—SAGS FOR SOFT-DRAWN COVERED COPPER WIRES FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size A. W. G.	Grade of Constr.	Temp. Deg. F.	Sags — Span Lengths—Feet: 100	125	150	175	200
			In.	In.	In.	In.	In.
No. 6	C	30	18	28	44	.....	.....
		60	21	32	48	.....	.....
		90	24	36	51	.....	.....
No. 4	A	30	17.5	28	45	.....	.....
		60	21	32	48	.....	.....
		90	24	35	51	.....	.....
No. 4	B & C	30	14.5	23	36	.....	.....
		60	18	27	40	.....	.....
		90	21.5	31	44	.....	.....
No. 2	A	30	14.5	23	36	49	.....
		60	18	27	40	54	.....
		90	21.5	31	44	58	.....
No. 2	B & C	30	11	17.5	28	40	55
		60	15	22	33	45	60
		90	18.5	26	38	50	64
No. 1	A	30	10.5	17.5	28	40	55
		60	15	22	33	45	60
		90	18.5	26	37	50.	65
No. 1	B & C	30	8.5	13.5	21.5	31	43
		60	12	18	27	37	48
		90	15.5	22.5	32	42	53
No. 0	All	30	8.5	13.5	20.5	29	39
		60	12	18	26	35	45
		90	15.5	22.5	31	39	51
No. 00	All	30	8.5	13.5	20	28	36
		60	12	18	25	33	42
		90	15.5	22.5	30	38	48
No. 0000	All	30	8.5	13.5	18.5	24.5	30
		60	12.0	18.	24	30	36
		90	16	22.5	29	36	42

TABLE 18—TENSIONS IN HARD AND MEDIUM-DRAWN BARE COPPER WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size A. W. G.	Grade of Constr.	Condition of Load °F.	Tensions — Span Length—Feet: 100	125	150	175	200	250	300	400	500
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	C	30° No load	94	92	76	.....	.....	.....	.....	.....	.....
		60° No load	63	65	62	.....	.....	.....	.....	.....	.....
		90° No load	47	53	54	.....	.....	.....	.....	.....	.....
		0° Loaded	442	503	520	.....	.....	.....	.....	.....	.....
No. 6	A	30° No load	150	145	120	.....	.....	.....	.....	.....	.....
		60° No load	99	105	99	.....	.....	.....	.....	.....	.....
		90° No load	74	85	80	.....	.....	.....	.....	.....	.....
		0° Loaded	570	630	670	.....	.....	.....	.....	.....	.....
No. 6	B	30° No load	180	180	165	.....	.....	.....	.....	.....	.....
		60° No load	120	125	120	.....	.....	.....	.....	.....	.....
		90° No load	84	95	100	.....	.....	.....	.....	.....	.....
		0° Loaded	590	650	710	.....	.....	.....	.....	.....	.....
No. 6	C	30° No load	180	180	165	125	.....	.....	.....	.....	.....
		60° No load	120	125	120	110	.....	.....	.....	.....	.....
		90° No load	84	95	100	96	.....	.....	.....	.....	.....
		0° Loaded	590	650	710	740	.....	.....	.....	.....	.....
No. 4	All	30° No load	290	280	270	260	240	185	160	.....	.....
		60° No load	190	200	200	210	200	170	150	.....	.....
		90° No load	135	150	160	175	170	155	145	.....	.....
		0° Loaded	740	840	900	960	1,000	1,000	990	.....	.....
No. 2	All	30° No load	460	450	510	590	650	540	470	380	350
		60° No load	300	310	380	440	500	430	400	350	340
		90° No load	210	240	290	340	400	370	370	340	330
		0° Loaded	1,000	1,100	1,250	1,350	1,450	1,550	1,550	1,600	1,600
No. 1	All	30° No load	580	520	650	740	820	730	670	540	490
		60° No load	380	400	470	550	630	600	580	510	470
		90° No load	270	300	370	430	500	500	520	480	450
		0° Loaded	1,200	1,250	1,450	1,600	1,700	1,800	1,900	1,900	1,900
No. 0	All	30° No load	730	720	820	930	1,050	970	950	760	710
		60° No load	480	500	600	700	800	790	790	710	670
		90° No load	340	380	460	540	630	660	690	650	630
		0° Loaded	1,400	1,500	1,650	1,850	2,000	2,150	2,200	2,300	2,250
No. 00	All	30° No load	920	910	1,050	1,150	1,300	1,300	1,300	1,050	960
		60° No load	600	630	750	880	1,000	1,050	1,100	950	910
		90° No load	430	480	580	680	790	850	930	880	850
		0° Loaded	1,700	1,750	1,950	2,150	2,350	2,550	2,900	2,650	2,650
No. 0000	All	30° No load	1,450	1,450	1,650	1,850	2,050	2,300	2,500	2,100	2,000
		60° No load	960	1,000	1,200	1,400	1,600	1,850	2,050	1,850	1,850
		90° No load	680	770	930	1,100	1,250	1,500	1,700	1,650	1,700
		0° Loaded	2,500	2,500	2,800	3,100	3,350	3,750	4,100	4,000	4,150

[a] Correspond to the sags of Table 15.

TABLE 19—TENSIONS IN HARD AND MEDIUM-DRAWN COVERED COPPER WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size A. W. G.	Grade of Constr.	Condition of Load °F.	Tensions — Span Length—Feet 100	125	150	175	200	250	300
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	C	30° No load	77	77	72	.....	.....	.....	.....
		60° No load	62	65	63	.....	.....	.....	.....
		90° No load	54	58	59	.....	.....	.....	.....
		0° Loaded	470	520	560	.....	.....	.....	.....
No. 6	A	30° No load	115	115	105	.....	.....	.....	.....
		60° No load	94	98	95	.....	.....	.....	.....
		90° No load	81	87	87	.....	.....	.....	.....
		0° Loaded	580	640	670	.....	.....	.....	.....
No. 6	B	30° No load	155	155	135	.....	.....	.....	.....
		60° No load	110	120	115	.....	.....	.....	.....
		90° No load	94	105	105	.....	.....	.....	.....
		0° Loaded	600	680	720	.....	.....	.....	.....
No. 6	C	30° No load	195	190	170	165	.....	.....	.....
		60° No load	140	145	140	145	.....	.....	.....
		90° No load	108	120	120	130	.....	.....	.....
		0° Loaded	640	710	760	820	.....	.....	.....
No. 4	All	30° No load	270	280	260	240	230	.....	.....
		60° No load	210	210	210	210	210	.....	.....
		90° No load	155	170	175	185	185	.....	.....
		0° Loaded	820	900	950	1,000	1,050	.....	.....
No. 2	All	30° No load	430	440	410	500	530	460	400
		60° No load	330	340	330	400	430	410	370
		90° No load	250	270	280	340	380	370	320
		0° Loaded	1,100	1,150	1,200	1,350	1,500	1,550	1,500
No. 1	All	30° No load	560	540	510	630	710	660	590
		60° No load	400	410	410	500	570	570	540
		90° No load	310	330	350	430	490	510	490
		0° Loaded	1,200	1,300	1,350	1,550	1,700	1,700	1,850
No. 0	All	30° No load	710	690	670	820	930	910	870
		60° No load	510	530	530	660	750	780	770
		90° No load	390	430	450	550	630	680	680
		0° Loaded	1,450	1,550	1,600	1,850	2,000	2,050	2,200
No. 00	All	30° No load	890	860	840	1,000	1,200	1,200	1,200
		60° No load	630	650	680	830	970	1,000	1,050
		90° No load	480	520	570	680	810	890	910
		0° Loaded	1,700	1,800	1,850	2,100	2,350	2,500	2,600
No. 0000	All	30° No load	1,350	1,350	1,400	1,650	1,850	2,250	2,450
		60° No load	960	1,000	1,100	1,300	1,550	1,900	2,050
		90° No load	730	810	920	1,100	1,300	1,600	1,750
		0° Loaded	2,450	2,500	2,650	3,000	3,300	3,850	4,200

[a] Correspond to sags of Table 16.

TABLE 20—TENSIONS IN SOFT-DRAWN COVERED COPPER WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size A. W. G.	Grade of Constr.	Condition of Load °F.	Tensions — Span Length—Feet 100	125	150	175	200
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 6	C	30° No load	97	94	87	.....	.....
		60° No load	82	85	80	.....	.....
		90° No load	71	76	75	.....	.....
		0° Loaded	540	590	610	.....	.....
No. 4	A	30° No load	140	140	125	.....	.....
		60° No load	120	120	115	.....	.....
		90° No load	105	115	110	.....	.....
		0° Loaded	670	710	720	.....	.....
No. 4	B & C	30° No load	175	165	155	.....	.....
		60° No load	140	145	140	.....	.....
		90° No load	115	130	130	.....	.....
		0° Loaded	720	770	800	.....	.....
No. 2	A	30° No load	280	270	250	240	.....
		60° No load	220	230	220	225	.....
		90° No load	185	200	200	210	.....
		0° Loaded	900	970	970	1,050	.....
No. 2	B & C	30° No load	350	350	310	300	290
		60° No load	260	280	270	270	260
		90° No load	210	240	240	240	240
		0° Loaded	980	1,050	1,100	1,100	1,150
No. 1	A	30° No load	430	430	380	370	350
		60° No load	320	340	330	330	320
		90° No load	260	290	290	300	300
		0° Loaded	1,100	1,200	1,200	1,250	1,250
No. 1	B & C	30° No load	560	540	490	470	450
		60° No load	390	410	400	400	400
		90° No load	310	330	340	350	360
		0° Loaded	1,250	1,300	1,350	1,400	1,450
No. 0	All	30° No load	710	690	670	630	630
		60° No load	510	530	530	530	540
		90° No load	460	430	450	480	480
		0° Loaded	1,450	1,550	1,600	1,600	1,700
No. 00	All	30° No load	890	860	850	840	840
		60° No load	630	650	680	700	720
		90° No load	490	520	570	600	640
		0° Loaded	1,700	1,800	1,850	1,900	2,000
No. 0000	All	30° No load	1,350	1,350	1,400	1,450	1,550
		60° No load	980	1,000	1,100	1,200	1,300
		90° No load	730	810	900	1,000	1,100
		0° Loaded	2,400	2,500	2,600	2,750	3,000

[a] Correspond to sags of Table 17.

TABLE 21—STRESSES IN HARD AND MEDIUM-DRAWN BARE COPPER WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size A. W. G.	Grade of Constr.	Condition of Load °F.	Stresses								
			Span Length—Feet								
			100	125	150	175	200	250	300	400	500
			Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.
No. 8	C	30° No load	7,200	7,150	5,900	.....	.....	.....	.....	.....	.....
		60° No load	4,800	5,000	4,800	.....	.....	.....	.....	.....	.....
		90° No load	3,600	4,100	4,150	.....	.....	.....	.....	.....	.....
		0° Loaded	34,100	38,800	40,250	.....	.....	.....	.....	.....	.....
No. 6	A	30° No load	7,200	7,150	5,900	.....	.....	.....	.....	.....	.....
		60° No load	4,800	5,000	4,800	.....	.....	.....	.....	.....	.....
		90° No load	3,600	4,100	4,150	.....	.....	.....	.....	.....	.....
		0° Loaded	27,400	30,500	32,350	.....	.....	.....	.....	.....	.....
No. 6	B	30° No load	8,800	8,700	8,000	.....	.....	.....	.....	.....	.....
		60° No load	5,800	6,000	5,900	.....	.....	.....	.....	.....	.....
		90° No load	4,100	4,650	4,850	.....	.....	.....	.....	.....	.....
		0° Loaded	28,400	31,750	34,400	.....	.....	.....	.....	.....	.....
No. 6	C	30° No load	8,800	8,700	8,000	6,150	.....	.....	.....	.....	.....
		60° No load	5,800	6,000	5,900	5,350	.....	.....	.....	.....	.....
		90° No load	4,100	4,650	4,850	4,650	.....	.....	.....	.....	.....
		0° Loaded	28,400	31,750	34,400	35,900	.....	.....	.....	.....	.....
No. 4	All	30° No load	8,800	8,700	8,200	8,000	7,200	5,600	4,850	.....	.....
		60° No load	5,800	6,000	6,150	6,300	6,100	5,100	4,550	.....	.....
		90° No load	4,100	4,650	4,950	5,350	5,250	4,700	4,400	.....	.....
		0° Loaded	22,700	25,700	27,400	29,400	30,500	30,600	30,300	.....	.....
No. 2	All	30° No load	8,800	8,700	9,850	11,200	12,400	10,300	8,950	7,250	6,650
		60° No load	5,800	6,000	7,200	8,400	9,600	8,250	7,700	6,800	6,500
		90° No load	4,100	4,650	5,600	6,450	7,600	7,150	7,000	6,500	6,250
		0° Loaded	19,400	21,000	23,650	26,000	28,100	29,300	30,200	30,500	30,900
No. 1	All	30° No load	8,800	8,700	9,850	11,200	12,400	11,150	10,250	8,250	7,500
		60° No load	5,800	6,000	7,200	8,400	9,600	9,100	8,850	7,750	7,150
		90° No load	4,100	4,650	5,600	6,450	7,600	7,600	7,850	7,300	6,850
		0° Loaded	18,200	19,250	21,700	24,000	26,000	27,500	28,700	28,900	29,000
No. 0	All	30° No load	8,800	8,700	9,850	11,200	12,400	11,700	11,400	9,200	8,550
		60° No load	5,800	6,000	7,200	8,400	9,600	9,500	9,500	8,500	8,050
		90° No load	4,100	4,650	5,600	6,450	7,600	7,900	8,250	7,800	7,600
		0° Loaded	17,100	18,200	20,200	22,200	24,150	26,000	26,800	27,500	27,000
No. 00	All	30° No load	8,800	8,700	9,850	11,200	12,400	12,400	12,500	10,100	9,250
		60° No load	5,800	6,000	7,200	8,400	9,600	10,000	10,400	9,100	8,650
		90° No load	4,100	4,650	5,600	6,450	7,600	8,150	8,950	8,400	8,100
		0° Loaded	16,100	16,800	18,800	20,800	22,500	24,200	27,600	25,400	25,400
No. 0000	All	30° No load	8,800	8,700	9,850	11,200	12,400	13,850	15,100	12,550	12,150
		60° No load	5,800	6,000	7,200	8,400	9,600	11,250	12,350	11,050	11,000
		90° No load	4,100	4,650	5,600	6,450	7,600	9,050	10,350	9,850	10,150
		0° Loaded	15,000	15,100	16,900	18,600	20,100	22,700	24,600	24,600	24,850

[a] Correspond to the tensions of Table 18.

TABLE 22—STRESSES IN HARD AND MEDIUM-DRAWN COVERED COPPER WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size A. W. G.	Grade of Constr.	Condition of Load °F.	Stresses						
			Span Length—Feet						
			100	125	150	175	200	250	300
			Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.
No. 8	C	30° No load	5,900	5,900	5,550	.....	.....	.....	.....
		60° No load	4,800	5,050	4,900	.....	.....	.....	.....
		90° No load	4,150	4,500	4,550	.....	.....	.....	.....
		0° Loaded	35,900	40,000	42,800	.....	.....	.....	.....
No. 6	A	30° No load	5,550	5,600	5,150	.....	.....	.....	.....
		60° No load	4,550	4,750	4,600	.....	.....	.....	.....
		90° No load	3,900	4,200	4,250	.....	.....	.....	.....
		0° Loaded	28,000	30,800	32,500	.....	.....	.....	.....
No. 6	B	30° No load	7,400	7,400	6,500	.....	.....	.....	.....
		60° No load	5,450	5,950	5,600	.....	.....	.....	.....
		90° No load	4,550	5,000	5,000	.....	.....	.....	.....
		0° Loaded	29,300	33,100	34,800	.....	.....	.....	.....
No. 6	C	30° No load	9,400	9,150	8,250	8,050	.....	.....	.....
		60° No load	6,800	7,100	6,800	6,950	.....	.....	.....
		90° No load	5,250	5,750	5,800	6,250	.....	.....	.....
		0° Loaded	31,000	34,600	37,000	39,800	.....	.....	.....
No. 4	All	30° No load	8,300	8,500	7,800	7,450	7,000	.....	.....
		60° No load	6,250	6,550	6,250	6,400	6,250	.....	.....
		90° No load	4,800	5,250	5,400	5,700	5,650	.....	.....
		0° Loaded	24,900	27,400	28,900	30,700	31,700	.....	.....
No. 2	All	30° No load	8,300	8,500	7,800	9,550	10,200	8,750	7,650
		60° No load	6,250	6,550	6,250	7,650	8,350	7,800	7,050
		90° No load	4,800	5,250	5,400	6,500	7,200	7,150	6,150
		0° Loaded	20,800	22,300	23,000	26,250	28,300	29,300	29,000
No. 1	All	30° No load	8,550	8,200	7,700	9,650	10,800	10,050	9,000
		60° No load	6,050	6,300	6,250	7,650	8,700	8,700	8,150
		90° No load	4,650	5,000	5,250	6,500	7,400	7,700	7,500
		0° Loaded	18,600	20,000	20,800	23,700	26,050	26,000	28,000
No. 0	All	30° No load	8,600	8,350	8,050	9,950	11,200	11,000	10,350
		60° No load	6,150	6,350	6,450	8,000	9,100	9,400	9,250
		90° No load	4,700	5,150	5,400	6,600	7,650	8,200	8,200
		0° Loaded	17,650	18,500	19,000	22,100	24,300	24,500	26,500
No. 00	All	30° No load	8,450	8,200	8,000	9,800	11,300	11,550	11,150
		60° No load	6,000	6,250	6,450	7,900	9,250	9,750	9,850
		90° No load	4,550	5,000	5,450	6,500	7,700	8,500	8,750
		0° Loaded	16,300	17,100	17,700	20,250	22,550	24,200	25,100
No. 0000	All	30° No load	8,150	8,000	8,500	9,850	11,200	13,650	14,600
		60° No load	5,800	6,050	6,600	7,900	9,250	11,350	12,450
		90° No load	4,400	4,850	5,500	6,500	7,700	9,550	10,550
		0° Loaded	14,650	15,000	15,800	17,900	19,950	23,200	25,250

[a] Correspond to the tensions of Table 19.

TABLE 23—STRESSES OF SOFT-DRAWN COVERED COPPER WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size A. W. G.	Grade of Constr.	Condition of Load °F.	Stresses — Span Length—Feet 100	125	150	175	200
			Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.	Lbs. per Sq. In.
No. 6	C	30° No load	4,700	4,550	4,250	.....	.....
		60° No load	3,950	4,100	3,900	.....	.....
		90° No load	3,400	3,700	3,650	.....	.....
		0° Loaded	26,250	28,550	29,500	.....	.....
No. 4	A	30° No load	4,350	4,250	3,850	.....	.....
		60° No load	3,600	3,750	3,550	.....	.....
		90° No load	3,150	3,450	3,300	.....	.....
		0° Loaded	20,400	21,600	22,000	.....	.....
No. 4	B & C	30° No load	5,300	5,100	4,750	.....	.....
		60° No load	4,200	4,400	4,300	.....	.....
		90° No load	3,550	3,900	3,900	.....	.....
		0° Loaded	21,850	23,500	24,300	.....	.....
No. 2	A	30° No load	5,300	5,100	4,750	4,700	.....
		60° No load	4,200	4,400	4,300	4,300	.....
		90° No load	3,550	3,850	3,900	4,000	.....
		0° Loaded	17,300	18,500	18,650	19,800	.....
No. 2	B & C	30° No load	6,650	6,700	6,000	5,700	5,500
		60° No load	5,050	5,350	5,150	5,150	5,000
		90° No load	4,050	4,500	4,550	4,700	4,700
		0° Loaded	18,750	20,300	20,800	21,500	21,750
No. 1	A	30° No load	6,500	6,500	5,800	5,550	5,300
		60° No load	4,800	5,150	4,950	4,950	4,850
		90° No load	3,900	4,400	4,400	4,500	4,500
		0° Loaded	17,050	18,400	18,550	18,850	18,950
No. 1	B & C	30° No load	8,550	8,200	7,500	7,050	6,850
		60° No load	6,000	6,250	6,050	6,000	6,000
		90° No load	4,650	5,000	5,200	5,300	5,500
		0° Loaded	18,800	20,100	20,500	21,300	21,800
No. 0	All	30° No load	8,600	8,350	8,050	7,650	7,500
		60° No load	6,150	6,350	6,450	6,400	6,500
		90° No load	4,700	5,150	5,400	5,750	5,800
		0° Loaded	17,650	18,500	19,000	19,600	20,250
No. 00	All	30° No load	8,500	8,200	8,100	8,000	8,000
		60° No load	6,000	6,250	6,500	6,650	6,850
		90° No load	4,650	5,000	5,450	5,750	6,100
		0° Loaded	16,400	17,000	17,750	18,300	19,000
No. 0000	All	30° No load	8,150	8,100	8,350	8,700	9,250
		60° No load	5,750	6,100	6,550	7,150	7,650
		90° No load	4,400	4,850	5,450	6,000	6,550
		0° Loaded	14,450	15,000	15,700	16,600	18,000

[a] Correspond to the tensions of Table 20.

2. MINIMUM SAGS WITH CORRESPONDING TENSIONS OF IRON AND STEEL WIRE

The following sags are those which will stress the conductor to nine-tenths of its elastic limit under the loading conditions specified in Order 1241.

This method has been employed for determining steel-wire sags for the reason that steel wire is generally used in rural districts where the chance that conductors of other materials will be strung on the same supporting structures is very remote and where long spans are used for the sake of economy. It is important, therefore, to know the minimum sags that can be used without overstressing the conductor.

When short spans are used and there is every possibility that the steel wire will be replaced with copper or that copper circuits will be strung on the same supports, it is recommended that the sags for copper wire of the same or nearest cross section be used, unless the sags specified for steel wire are the greater, in which case the latter sags should be used for both the copper and steel conductors. This construction will eliminate a ragged appearance in the line and will also assist in preventing conductors from swinging together.

Under the assumed conditions, the tension in the conductor will be as great for short spans as for long ones. The longitudinal strength of the structures for such spans must, in order to withstand these stresses, be comparable to the strength of structures for long spans. The advantage of using short spans is accordingly lost unless the sags are increased.

Since the sags for iron and steel wire have been calculated on the basis of the material being stressed to nine-tenths of the average elastic limit or 0.45 of the ultimate strength, under loaded conditions, the values for the sags and tensions given in these tables are limiting values.

A series of tables of stresses is not included, since the value under loaded conditions is always that given in the preceding paragraph. The stress under other conditions can be readily computed from the table of tensions.

TABLE 24—SAGS FOR EXTRA BEST BEST (E. B. B.) IRON WIRE FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size of Wire	Temp. Deg. F.	Sags — Span Length—Feet										
		100	125	150	175	200	250	300	400	500	600	700
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8 Stl. W. G.	30	28.5	47.5	70.5	97	130	208	.....	.....	.....	.....	.....
	60	31	48.5	71	99.5	132	209	.....	.....	.....	.....	.....
	90	32.5	49.5	73	100	133	210	.....	.....	.....	.....	.....
No. 6 Stl. W. G.	30	18	31.5	49	68.5	94.5	150	.....	.....	.....	.....	.....
	60	21	34.5	51	72	97	152	.....	.....	.....	.....	.....
	90	23.5	37	54	74.5	100	155	.....	.....	.....	.....	.....
No. 4 Stl. W. G.	30	11	21.5	34.5	49.5	69	110	.....	.....	.....	.....	.....
	60	14.5	25	37.5	53	71	112	.....	.....	.....	.....	.....
	90	17.5	28.5	40.5	56	75.1	116	.....	.....	.....	.....	.....
¼ in. 7 strand	30	7.3	17	30.5	46.5	64.5	109	162.5	305	.....	.....	.....
	60	10.2	21	34	50.5	68	111.5	165.5	308	.....	.....	.....
	90	13.5	24	37	53	71	116	168.5	310	.....	.....	.....
5/16 in. 7 strand	30	3.8	7.2	13	22	33	61	95.5	183	300	444	.....
	60	5.1	9.9	17	26.5	38	66	100	188	304	448	.....
	90	7.4	13.5	21.5	31	42.5	70.5	105	193	308	453	.....
⅜ in. 7 strand	30	3.9	7.0	11.7	19	27.5	51.5	81.5	158	258	383	534
	60	5.2	9.3	15.5	23	32.5	56.5	86.5	163	262	388	539
	90	7.1	12.5	19	27.5	37.5	61.5	91.5	168	267	393	543

TABLE 25—SAGS FOR BEST BEST (B. B.) IRON WIRES FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size of Wire	Temp. Deg. F.	Sags — Span Length—Feet										
		100	125	150	175	200	250	300	400	500	600	700
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8 Stl. W. G.	30	23	40.5	59.5	84	112.5	181	.....	.....	.....	.....	.....
	60	25	42	62	86.5	113	183	.....	.....	.....	.....	.....
	90	27	43.5	63	87.5	115	184	.....	.....	.....	.....	.....
No. 6 Stl. W. G.	30	13	25	40	58.5	78.5	129	.....	.....	.....	.....	.....
	60	16	28.5	43.5	61.5	81.5	133	.....	.....	.....	.....	.....
	90	19.5	31.5	46	65	84.5	136	.....	.....	.....	.....	.....
No. 4 Stl. W. G.	30	7.5	16	27.5	41.5	56.5	94.5	.....	.....	.....	.....	.....
	60	10.6	20	31	45	60	98	.....	.....	.....	.....	.....
	90	14.5	23	34	49	63.5	102	.....	.....	.....	.....	.....
¼ in. 7 strand	30	4.8	11.4	23	37	53.5	93	141	268	.....	.....	.....
	60	6.7	15	27	41	57	96.5	144.5	271	.....	.....	.....
	90	9.5	19	30	44.5	61	100	148	275	.....	.....	.....
5/16 in. 7 strand	30	3.1	5.6	9.7	16.5	25.5	50.5	81.5	161	266	398	555
	60	4	7.4	13	21	30.5	55.5	87	166	271	403	560
	90	5.6	10	17	25.5	35.5	61	92	171	276	407	564
⅜ in. 7 strand	30	3.3	5.6	9.1	14.5	21.5	41.0	67.5	136	226	339	473
	60	4.5	7.2	11.6	18	26.0	47	73.5	142	232	344	479
	90	5.5	9.5	15.0	22.0	31.0	52	79	148	238	350	484

TABLE 26—SAGS FOR ORDINARY GRADE STEEL WIRES FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size of Wire	Temp. Deg. F.	Sags — Span Length—Feet										
		100	125	150	175	200	250	300	400	500	600	700
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8 Stl. W. G.	30	21	37	55.5	79	104	168	249	.....	.....	.....	.....
	60	23	38.5	57.5	80	105	170	251	.....	.....	.....	.....
	90	25	40.5	59.5	82	107.5	173	251	.....	.....	.....	.....
No. 6 Stl. W. G.	30	11.4	23	37.5	54	73	122	179	.....	.....	.....	.....
	60	15	26.5	40.5	57	76.5	123	182	.....	.....	.....	.....
	90	18	30	44	60.5	79.5	127	185	.....	.....	.....	.....
No. 4 Stl. W. G.	30	6.4	14.5	25	38	52	83	132	.....	.....	.....	.....
	60	9.8	18.5	29	41	56.5	91.5	134	.....	.....	.....	.....
	90	13.5	22	33	45	60	95	138	.....	.....	.....	.....
¼ in. 7 strand	30	3.3	7.1	16.5	26.5	41	75.5	117	225	362	.....	.....
	60	4.5	9.8	21	31	45.5	79.5	121	230	366	.....	.....
	90	6.4	13.5	25	35.5	49.5	83.5	125	233	370	.....	.....
5/16 in. 7 strand	30	2.6	4.6	7.7	11.5	19.5	40	68	147.5	232	348	487
	60	3.4	6	10.1	15	24.5	46.5	74	152	237	353	492
	90	4.6	7	13.5	19.5	29	52	80	156	243	359	497
⅜ in. 7 strand	30	2.6	4.3	6.6	9.9	14.5	28.0	48.0	105.0	180	272	383
	60	4.4	5.3	8.3	12.5	18	33.0	55.0	112	187	279	390
	90	4.0	6.8	10.7	16	22.5	39.5	61.0	118.5	193	285	397

TABLE 27—SAGS FOR SIEMENS-MARTIN STEEL WIRES FOR DIFFERENT SPAN LENGTHS

(At 30°, 60° and 90° F., wires without load.)

Size of Wire	Temp. Deg. F.	Sags — Span Length—Feet											
		100	125	150	175	200	250	300	400	500	600	700	1000
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8. Stl. W. G.	30	5.5	17	31.5	49	67.0	113	170	317	.....	.....	.....	.....
	60	9.1	20	34.5	51.0	70	113	172.5	320	.....	.....	.....	.....
	90	12.7	24	38	54	73	117	175	325	.....	.....	.....	.....
No. 6 Stl. W. G.	30	3.3	7.3	16	28	43	77.5	119.0	230	.....	.....	.....	.....
	60	5.2	10.7	20.5	32	47.5	81.0	123	233	.....	.....	.....	.....
	90	7.7	15	25	38.5	51.5	85.5	127	238	.....	.....	.....	.....
No. 4 Stl. W. G.	30	2.4	4.6	8.5	15.0	25.0	50	82	164	.....	.....	.....	.....
	60	3.5	6.5	12	20	30	55.5	86.5	168	.....	.....	.....	.....
	90	5.0	9.6	16.5	25.5	35.5	61.5	91.5	173	.....	.....	.....	.....
¼ in. 7 strand	30	1.9	3.3	5.4	8.9	15	37.0	69.5	152	258	392	.....	.....
	60	2.2	3.4	5.7	11.4	19	43.5	74.5	158	264	397	.....	.....
	90	2.7	5	8.6	15	24	49	81	164	264	402	.....	.....
5/16 in. 7 strand	30	1.8	3	4.8	6.8	9.7	19	36	89	162	252	360	.....
	60	2.2	3.6	5.6	8.2	12	23.5	42.5	97.5	170	260	367	.....
	90	2.7	4.5	7.9	10.4	15	29	49.5	105	177	267	374	.....
⅜ in. 7 strand	30	1.7	2.7	4	5.6	7.5	13	21.5	50	99	165	245	564
	60	1.9	3.1	4.6	6.5	8.8	15.5	25	57.5	109	175	254	574
	90	2.2	3.6	5.4	7.6	10.5	18.5	29.5	65.5	118	184	264	583

TABLE 28—TENSIONS FOR EXTRA BEST BEST (E. B. B.) IRON WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size Stl. W. G.	Conditions of load and Temp. F.	Tensions										
		Span Length—Feet										
		100	125	150	175	200	250	300	400	500	600	700
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30° No load	37	36	35	34	34	34	.....	.....	.....	.....	.....
	60° No load	35	35	34	34	34	33	.....	.....	.....	.....	.....
	90° No load	34	33	33	33	33	33	.....	.....	.....	.....	.....
	0° Loaded	422	422	422	422	422	422	.....	.....	.....	.....	.....
No. 6	30° No load	86	75	70	67	65	64	.....	.....	.....	.....	.....
	60° No load	72	69	66	65	64	63	.....	.....	.....	.....	.....
	90° No load	64	64	64	63	63	62	.....	.....	.....	.....	.....
	0° Loaded	592	592	592	592	592	592	.....	.....	.....	.....	.....
No. 4	30° No load	188	149	134	127	122	118	.....	.....	.....	.....	.....
	60° No load	144	132	123	120	118	115	.....	.....	.....	.....	.....
	90° No load	118	117	115	114	113	112	.....	.....	.....	.....	.....
	0° Loaded	818	818	818	818	818	818	.....	.....	.....	.....	.....
¼ in. 7 strand	30° No load	258	169	138	124	119	109	106	102	.....	.....	.....
	60° No load	183	141	124	116	113	106	104	101	.....	.....	.....
	90° No load	140	122	114	109	107	104	102	101	.....	.....	.....
	0° Loaded	810	810	810	810	810	810	810	810	.....	.....	.....
5/16 in. 7 strand	30° No load	832	682	541	440	380	323	299	278	268	265	.....
	60° No load	611	499	413	364	332	300	285	272	265	262	.....
	90° No load	426	368	332	310	296	280	272	266	262	260	.....
	0° Loaded	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	.....
⅜ in. 7 strand	30° No load	1,134	984	849	725	642	540	492	452	437	427	422
	60° No load	863	747	656	592	544	491	463	438	420	422	418
	90° No load	625	560	523	494	475	451	438	426	421	417	415
	0° Loaded	1,711	1,711	1,711	1,711	1,711	1,711	1,711	1,711	1,711	1,711	1,711

[a] Correspond to the sags of Table 24.

TABLE 29—TENSIONS FOR BEST BEST (B. B.) IRON WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size of Wire	Conditions of load and Temp. F.	Tensions										
		Span Length—Feet										
		100	125	150	175	200	250	300	400	500	600	700
		Lbs.	Lbs.	Lb.s	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8 Stl. W. G.	30° No load	46	42	41	40	39	38	.....	.....	.....	.....	.....
	60° No load	43	41	40	39	39	38	.....	.....	.....	.....	.....
	90° No load	40	39	38	38	38	38	.....	.....	.....	.....	.....
	0° Loaded	474	474	474	474	474	474	.....	.....	.....	.....	.....
No. 6 Stl. W. G.	30° No load	114	93	84	80	77	73	.....	.....	.....	.....	.....
	60° No load	92	83	78	75	74	72	.....	.....	.....	.....	.....
	90° No load	79	76	74	73	72	72	.....	.....	.....	.....	.....
	0° Loaded	665	665	665	665	665	665	.....	.....	.....	.....	.....
No. 4 Stl. W. G.	30° No load	275	200	168	154	147	137	.....	.....	.....	.....	.....
	60° No load	193	166	149	142	138	133	.....	.....	.....	.....	.....
	90° No load	146	138	134	132	129	128	.....	.....	.....	.....	.....
	0° Loaded	915	915	915	915	915	915	.....	.....	.....	.....	.....
¼ in. 7 strand	30° No load	396	257	185	155	141	127	121	115	.....	.....	.....
	60° No load	281	195	158	141	132	122	118	114	.....	.....	.....
	90° No load	197	156	139	129	125	119	115	113	.....	.....	.....
	0° Loaded	900	900	900	900	900	900	900	900	.....	.....	.....
5/16 in. 7 strand	30° No load	1,015	876	731	593	494	392	349	315	301	294	290
	60° No load	779	661	552	465	412	354	328	305	296	290	288
	90° No load	564	482	422	381	354	324	310	297	291	287	286
	0° Loaded	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530
⅜ in. 7 strand	30° No load	1,354	1,229	1,099	950	831	673	591	521	494	481	472
	60° No load	1,070	963	854	757	687	593	544	501	483	473	468
	90° No load	804	729	660	615	576	531	506	482	472	466	463
	0° Loaded	1,891	1,891	1,891	1,891	1,891	1,891	1,891	1,891	1,891	1,891	1,891

[a] Correspond to the sags of Table 25.

TABLE 30—TENSIONS FOR ORDINARY GRADE STEEL WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size Stl. W. G.	Conditions of load and Temp. F.	Tensions — Span Length—Feet										
		100	125	150	175	200	250	300	400	500	600	700
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30° No load	52	46	43	43	42	41	40	.....	.....	.....	.....
	60° No load	46	43	42	41	41	40	40	.....	.....	.....	.....
	90° No load	42	42	41	40	40	40	39	.....	.....	.....	.....
	0° Loaded	508	508	508	508	508	508	508	.....	.....	.....	.....
No. 6	30° No load	132	103	92	87	84	80	77	.....	.....	.....	.....
	60° No load	100	89	84	80	79	77	76	.....	.....	.....	.....
	90° No load	83	80	78	77	76	76	75	.....	.....	.....	.....
	0° Loaded	712	712	712	712	712	712	712	.....	.....	.....	.....
No. 4	30° No load	318	225	186	169	158	148	143	.....	.....	.....	.....
	60° No load	211	176	162	156	147	142	139	.....	.....	.....	.....
	90° No load	153	147	143	139	138	136	134	.....	.....	.....	.....
	0° Loaded	982	982	982	982	982	982	982	.....	.....	.....	.....
¼ in. 7 strand	30° No load	566	415	285	216	183	156	145	136	134	.....	.....
	60° No load	419	298	222	185	166	148	140	134	133	.....	.....
	90° No load	291	218	181	162	152	141	136	132	131	.....	.....
	0° Loaded	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	.....	.....
5/16 in. 7 strand	30° No load	1,192	1,070	924	782	649	491	416	363	345	333	328
	60° No load	931	819	698	596	514	426	384	350	336	328	325
	90° No load	729	610	518	462	422	380	356	339	320	323	322
	0° Loaded	1,710	1,710	1,710	1,710	1,710	1,710	1,710	1,710	1,710	1,710	1,710
⅜ in. 7 strand	30° No load	1,726	1,630	1,506	1,372	1,238	990	829	677	619	592	577
	60° No load	1,402	1,316	1,203	1,093	992	830	728	635	597	579	567
	90° No load	1,088	1,017	931	857	792	705	652	600	576	566	558
	0° Loaded	2,249	2,249	2,249	2,249	2,249	2,249	2,249	2,249	2,249	2,249	2,249

[a] Correspond to the sags of Table 26.

TABLE 31—TENSIONS FOR SIEMENS-MARTIN STEEL WIRE FOR DIFFERENT SPAN LENGTHS [a]

Size Stl. W. G.	Conditions of load and Temp. F.	Tensions — Span Length—Feet											
		100	125	150	175	200	250	300	400	500	600	700	1,000
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8 Stl. W. G.	30° No load	189	99	76	67	63	60	58	56	.....	.....	.....	.....
	60° No load	119	81	69	64	61	58	57	56	.....	.....	.....	.....
	90° No load	84	70	63	61	59	57	56	55	.....	.....	.....	.....
	0° Loaded	694	694	694	694	694	694	694	694	.....	.....	.....	.....
No. 6 Stl. W. G.	30° No load	452	310	219	166	147	126	118	111	.....	.....	.....	.....
	60° No load	279	211	168	143	131	119	113	109	.....	.....	.....	.....
	90° No load	204	160	138	125	120	113	110	107	.....	.....	.....	.....
	0° Loaded	966	966	966	966	966	966	966	966	.....	.....	.....	.....
No. 4 Stl. W. G.	30° No load	835	686	536	417	342	261	230	207	.....	.....	.....	.....
	60° No load	598	478	387	322	281	239	213	201	.....	.....	.....	.....
	90° No load	410	337	287	250	232	213	203	193	.....	.....	.....	.....
	0° Loaded	1,347	1,347	1,347	1,347	1,347	1,347	1,347	1,347	.....	.....	.....	.....
¼ in. 7 strand	30° No load	1,003	895	779	641	505	315	244	199	184	177	.....	.....
	60° No load	845	740	628	505	396	272	226	192	181	175	.....	.....
	90° No load	689	590	488	389	314	249	210	186	178	173	.....	.....
	0° Loaded	1,350	1,350	1,350	1,350	1,350	1,350	1,350	1,350	1,350	1,350	.....	.....
5/16 in. 7 strand	30° No load	1,730	1,650	1,546	1,430	1,300	1,030	794	567	488	454	436	.....
	60° No load	1,458	1,378	1,280	1,172	1,058	832	666	520	466	442	428	.....
	90° No load	1,189	1,113	1,025	931	830	675	573	483	447	430	421	.....
	0° Loaded	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	.....
⅜ in. 7 strand	30° No load	2,652	2,566	2,495	2,419	2,315	2,109	1,868	1,411	1,114	967	891	801
	60° No load	2,292	2,235	2,166	2,097	2,006	1,805	1,596	1,231	1,019	915	859	788
	90° No load	1,964	1,907	1,844	1,778	1,696	1,517	1,368	1,083	941	870	829	776
	0° Loaded	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061

[a] Correspond to sags of Table 27.

3. MECHANICAL DATA FOR COPPER AND STEEL WIRE

(a) *Copper Wire.* The following table contains data on the ultimate strength and per cent of elongation before failure of hard, medium, and soft copper wire as given in the 1915 report of the American Society for Testing Materials.

The elastic limit as given by the same society is 55 to 60 per cent of the ultimate strength for hard-drawn copper and 50 to 55 per cent for medium-drawn copper. There is no definite elastic limit for soft copper, but its behavior, after having a slight preliminary stretch, may be considered as approximately that of an elastic material having a limit of elasticity of 10,000 to 15,000 pounds per square inch.

The modulus of elasticity has been taken at 16,000,000 for all grades of copper. The coefficient of linear thermal expansion per degree F. has been taken as 0.96×10^{-5}.

TABLE 32—MECHANICAL DATA FOR COPPER WIRE

Size A. W. G.	Diameter	Hard-drawn		Medium-drawn			Soft-drawn	
		Average Ultimate Strength	Average Elongation	Average Minimum Ultimate Strength	Average Maximum Ultimate Strength	Elongation	Average Ultimate Strength	Average Elongation
	In.	Lbs. Per Sq. In.	Per Cent	Lbs. Per Sq. In.	Lbs. Per Sq. In.	Per Cent	Lbs. Per Sq. In.	Per Cent
No. 8	0.128	63,700	1.06	49,660	56,660	1.08	.....	.....
No. 6	.162	62.100	1.14	49,000	56,000	1.15	.....	.....
No. 4	.204	60,100	1.24	48,330	55,330	1.25	37,000	30
No. 2	.258	57,600	1.98	47,000	54,000	2.50	.....	.....
No. 1	.289	56,100	2.17	46,000	53,000	2.75	.....	.....
No. 0	.325	54,500	2.40	45,000	52,000	3.00	.....	.....
No. 00	.365	52,800	2.80	44,000	51,000	3.25	36,000	35
No. 000	.41	51,000	3.25	43,000	50,000	3.60	.....	.....
No. 0000	.46	49,000	3.75	42,000	49,000	3.75	.....	.....

(b) *Iron and Steel Wire and Cables.* The following table contains data on the strength of various grades of iron and steel wire and cables. The data for cables was obtained from tests made by the American Telephone and Telegraph Co., and by the Bureau of Standards, and for solid wire from manufacturers tables.

The elastic limit for different samples of the same grade of wire will vary over a considerable range, the minimum value being

0.45 of the ultimate strength and the maximum 0.55 of the ultimate. The average elastic limit, therefore, has been taken as one-half of the ultimate strength.

However, in order that the minimum value of elastic limit may not be exceeded in practice, the sags for iron and steel wire were all figured on the basis of a maximum stress of nine-tenths of the average elastic limit under the most extreme loading condition.

The coefficient of linear expansion for iron and steel per degree F. has taken as 0.67×10^{-5}.

TABLE 33—MECHANICAL DATA FOR IRON AND STEEL WIRES AND CABLES

Size Nominal	Actual Diameter	Area	Ultimate Strength of—				Modulus of Elasticity x 10^{-6} of—	
			EBB Iron	BB Iron	Ordinary Grade Steel	Siemens-Martin Steel	EBB and BB	Ordinary Grade and Siemens-Martin
	In.	Sq. In.	Lbs. Per Sq. In.	Lbs. Per Sq. In.	Lbs. Per Sq. In.	Lbs. Per Sq. In.	Lbs. Per Sq. In.	Lbs. Per Sq. In.
Solid:								
No. 8 Stl. W. G.	.162	.0206	45,450	51,000	54,700	74,800	26	29
No. 6 Stl. W. G.	.192	.0289	45,450	51,000	54,600	74,000	26	29
No. 4 Stl. W. G.	.225	.0398	45,500	51,000	54,600	75,000	26	29
Stranded:								
¼ in., 7— 83 mils	.249	.0379	47,500	52,700	60,700	79,200	19	21
$\frac{5}{16}$ in., 7—109 mils	.327	.0654	47,400	52,000	58,100	73,400	19	21
⅜ in., 7—120 mils	.36	.0792	48,000	53,000	63,200	85,900	19	21

4. RESULTANT CONDUCTOR LOADINGS

The following table gives the resultant loading in pounds per foot for conductors of various sizes and material. The calculations are based on the assumed loadings given in Order 1241 and on average values of the diameters of weather-proof wires. The over-all diameters of covered wires supplied by various manufacturers vary considerably and hence average values are chosen. This is also true of the sizes of the strands which make up stranded steel cables. The values of loading are based on the sizes of strands given in the table.

TABLE 34—CALCULATED LOADING FOR CONDUCTORS OF VARIOUS SIZES

Size of Conductor	Diameter over all	Weight of conductor	Resultant loading
	In.	Lbs. Per Ft.	Lbs. Per Ft.
Bare solid copper, A. W. G.			
No. 12	0.081	0.020	0.816
No. 10	.102	.032	.839
No. 8	.128	.050	.872
No. 6	.162	.0795	.917
No. 4	.204	.126	.981
No. 2	.258	.201	1.075
No. 1	.289	.253	1.137
No. 0	.325	.320	1.214
No. 00	.365	.403	1.309
No. 0000	.460	.641	1.575
T. B. W. P. solid copper, A. W. G.			
No. 12	.21	.035	.937
No. 10	.25	.053	.982
No. 8	.26	.075	1.003
No. 6	.32	.112	1.075
No. 4	.38	.164	1.164
No. 2	.44	.260	1.278
No. 1	.47	.316	1.345
No. 0	.50	.407	1.435
No. 00	.53	.502	1.532
No. 0000	.65	.767	1.850
T. B. W. P. stranded copper, A. W. G.			
No. 2	.444	.270	1.285
No. 1	.518	.328	1.395
No. 0	.620	.424	1.557
No. 00	.662	.522	1.666
No. 0000	.785	.800	1.993
250,000 cir. mils	.862	.985	2.217
350,000 cir. mils	.978	1.345	2.619
500,000 cir. mils	1.108	1.894	3,217
750,000 cir. mils	1.343	2.822	4.272
1,000,000 cir. mils	1.531	3.674	5,230
Bare stranded aluminum, A. W. G.			
No. 2	.291	.061	1.023
No. 1	.328	.077	1.065
No. 0	.368	.097	1.112
No. 00	.414	.122	1.168
No. 0000	.522	.195	1.312
Bare steel—solid and stranded.			
No. 8 Stl. W. G. solid	.162	.069	.912
No. 6 Stl. W. G. solid	.192	.097	.953
No. 4 Stl. W. G. solid	.225	.134	1.006
¼ in., 7— 83 mils. str.	.249	.125	1.022
$\frac{5}{16}$ in., 7—109 mils. str	.327	.210	1.142
⅜ in., 7—120 mils. str	.360	.295	1.230
Bare solid copper No. 8 B. W. G.	.165	.082	.921
Bare solid iron No. 12 B. W. G.	.109	.032	.846
Bare solid iron No. 14 B. W. G.	.083	.019	.816
Bare solid copper No. 12 N. B. S.	.104	.033	.842
Bare solid copper No 14 N. B. S.	.080	.019	.814

APPENDIX B. LOADING DATA, MECHANICAL CHARACTERISTICS AND RECOMMENDED SETTINGS OF OVERHEAD SUPPORTS

1. DATA FOR COMPUTING VERTICAL AND TRANSVERSE STRENGTH REQUIRED FOR LINE SUPPORTS

(a) *Assumed Vertical and Transverse Loads on Conductors of Various Materials and Sizes.* The vertical loads on supports due to the conductors with or without ice based on the assumptions of Order 1242—a, are given in Table 35. Values for vertical loadings for wires of other sizes and materials can be readily computed. The over-all diameters of weather-proof wire supplied by different manufacturers vary considerably, and hence average values are chosen for the table.

TABLE 35—VERTICAL LOADS ON CONDUCTOR SUPPORTS

Size of Conductor	Diameter over all	Conductor+ 0.5 inch ice
	In.	Lbs. Per Ft.
Bare solid copper, A. W. G.		
No. 12	0.081	0.381
No. 10	.102	.406
No. 8	.128	.440
No. 6	.162	.491
No. 4	.204	.564
No. 2	.258	.673
No. 1	.289	.744
No. 0	.325	.833
No. 00	.365	.940
No. 0000	.460	1.238
T. B. W. P. solid copper, A. W. G.		
No. 12	.21	.476
No. 10	.25	.519
No. 8	.26	.547
No. 6	.32	.621
No. 4	.38	.711
No. 2	.44	.843
No. 1	.47	.919
No. 0	.50	1.029
No. 00	.53	1.143
No. 0000	.65	1.482
T. B. W. P. stranded copper, A. W. G.		
No. 2	.444	.855
No. 1	.518	.961
No. 0	.62	1.120
No. 00	.662	1.245
No. 0000	.785	1.599
250,000 cir. mils	.862	1.832
350,000 cir. mils	.978	2.264
500,000 cir mils	1.108	2.894
750,000 cir. mils	1.343	3.969
1,000,000 cir. mils	1.531	4.937

TABLE 35—Continued

Size of Conductor	Diameter over all	Conductor + 0.5 inch ice
	In	Lbs. Per Ft
Bare stranded aluminum, A. W. G.		
No. 2	.291	.553
No. 1	.328	.592
No. 0	.368	.636
No. 00	.414	.691
No. 0000	.522	.831
Bare solid copper, No. 8 B. W. G.	.165	.495
Bare solid copper, No. 12 N. B. S.	.104	.409
Bare solid copper, No. 14 N. B. S.	.080	.380
Bare solid iron, No. 12 B. W. G.	.109	.410
Bare solid iron, No. 14 B. W. G.	.083	.381
Bare steel—solid and stranded.		
No. 8 Stl. W. G.—solid	.162	.481
No. 6 Stl. W. G.—solid	.192	.527
No. 4 Stl. W. G.—solid	.225	.587
¼ in., 7— 83 mils., stranded	.249	.590
5/16 in., 7—109 mils., stranded	.327	.725
⅜ in., 7—120 mils., stranded	.360	.830

The values of transverse loads computed from Orders 1240—b, 1242—b, 1280—c, and 1281 for various grades of construction (A, B, C, D, or E) are given in Table 36.

These values are computed on the assumption that a definite fiber stress, equal to half the ultimate strength of the material, will be considered as a limiting value, and that the loading specified in Orders 1242 and 1280 for Grades B and D will be modified to apply to the other grades. Thus the column headed "B, D" is computed for an eight-pound wind and a half inch of ice on conductors. The next column to the right gives values two-thirds as great. The column headed A gives values 50 per cent larger than for B. It must be remembered that for signal poles not guyed, double strength is called for and this is most easily figured by simply doubling the quantity given rather than to introduce different working stresses in the material.

Values for transverse loadings for wires of other outside diameters can be readily computed by adding one inch to the outside diameter in inches, which will give the force in column A. This results because one must divide by 12 to convert to feet, multiply by 8 to give values for B and increase these by one-half for A.

TABLE 36—EQUIVALENT TRANSVERSE FORCE ON WIRES

Actual force on ice-covered wire modified for grade (pounds per conductor per foot.)

Size of Conductor	A	B D	C E
Bare solid, A. W. G.			
No. 12	1.08	0.721	0.480
No. 10	1.10	.735	.490
No. 8	1.13	.752	.501
No. 6	1.16	.775	.516
No. 4	1.20	.803	.535
No. 2	1.26	.839	.559
No. 1	1.29	.859	.573
No. 0	1.33	.883	.589
No. 00	1.37	.910	.607
No. 0000	1.46	.973	.649
T. B. W. P. solid, A. W. G.			
No. 12	1.21	0.807	0.538
No. 10	1.25	.833	.556
No. 8	1.26	.840	.560
No. 6	1.32	.880	.587
No. 4	1.38	.920	.613
No. 2	1.44	.960	.640
No. 1	1.47	.980	.653
No. 0	1.50	1.000	.667
No. 00	1.53	1.020	.680
No. 0000	1.65	1.100	.733
T. B. W. P. stranded, A. W. G.			
No. 2	1.44	0.963	0.642
No. 1	1.52	1.012	.675
No. 0	1.62	1.080	.720
No. 00	1.66	1.108	.739
No. 0000	1.79	1.190	.793
250,000 cir. mils	1.86	1.241	.828
350,000 cir. mils	1.98	1.319	.879
500,000 cir. mils	2.11	1.405	.937
750,000 cir. mils	2.34	1.58	1.041
1,000,000 cir. mils	2.53	1.69	1.125
Bare stranded, A. W. G.			
No. 2	1.29	0.861	0.574
No. 1	1.33	.885	.590
No. 0	1.38	.917	.611
No. 00	1.41	.943	.628
No. 0000	1.52	1.015	.676
Bare solid, No. 8, B. W. G.	1.17	0.777	0.518
Bare solid, No. 12, B. W. G.	1.11	.739	.493
Bare solid, No. 14, B. W. G.	1.08	.722	.481
Bare solid, No. 12, N. B. S.	1.10	.736	.491
Bare solid, No. 14, N. B. S.	1.08	.720	.480
Bare solid and stranded.			
No. 8 Stl. W. G.—solid	1.162	.773	.516
No. 6 Stl. W. G.—solid	1.192	.794	.530
No. 4 Stl. W. G.—solid	1.225	.816	.544
¼ in., 7— 83 mils. str	1.249	.833	.555
5/16 in., 7—109 mils. str	1.327	.884	.590
⅜ in., 7—120 mils. str	1.360	.906	.604

(b) *Calculation of Moments of Resistance of Poles.* The resisting moments of sound chestnut, western red cedar, and cypress poles for varying ground-line circumferences given in Table 37 are based on a maximum allowable fiber stress of 2500 pounds per square inch, which is one-half of the assumed ultimate strength.

The resisting moments of northern white cedar and redwood poles are based upon an allowable fiber stress of 1800 pounds per square inch, which is one-half of the assumed ultimate strength.

For other varieties of wood poles, the resisting moments will be in the same proportion to those tabulated as the relative ultimate strengths of the different woods.

For sound southern yellow pine, the same values as for chestnut may be used. Values 30 per cent greater than for chestnut may be used for dense southern yellow pine meeting the standard of the American Society for Testing Materials. Southern yellow pine should not be used for supporting structures unless creosoted or subjected to some other 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 37—RESISTING MOMENTS OF SOUND WOOD POLES FOR VARIOUS GROUND-LINE CIRCUMFERENCES, BASED ON A MAXIMUM ALLOWABLE FIBER STRESS OF 2500 POUNDS PER SQUARE INCH FOR CHESTNUT, WESTERN RED CEDAR, AND CYPRESS, AND 1800 POUNDS PER SQUARE INCH FOR NORTHERN WHITE CEDAR AND REDWOOD

Circumference at ground in inches	Resisting moments in pound-feet for fiber stress of		Circumference at ground in inches	Resisting moments in pound-feet for fiber stress of	
	2,500 pounds per square inch	1,800 pounds per square inch		2,500 pounds per square inch	1,800 pounds per square inch
24	9,120	6,560	50	82,400	59,400
25	10,300	7,420	51	87,500	63,000
26	11,600	8,350	52	92,700	66,800
27	13,000	9,350	53	98,200	70,700
28	14,500	10,400	54	103,800	74,800
29	16,100	11,600	55	109,700	79,000
30	17,800	12,800	56	115,800	83,400
31	19,650	14,150	57	122,100	87,900
32	21,600	15,600	58	128,700	92,650
33	23,700	17,100	59	135,400	97,750
34	25,900	18,700	60	142,500	102,600
35	28,300	20,400	61	149,700	107,800
36	30,800	22,150	62	157,200	113,200
37	33,400	24,050	63	164,900	118,700
38	36,200	26,100	64	172,900	124,500
39	39,100	28,200	65	181,100	130,400
40	42,200	30,400	66	189,600	136,500
41	45,450	32,700	67	198,400	142,800
42	48,900	35,200	68	207,400	149,300
43	52,400	37,750	69	216,700	156,000
44	56,200	40,450	70	226,200	162,900
45	60,100	43,300	71	236,000	170,000
46	64,200	46,200	72	246,200	177,300
47	68,500	49,300	73	256,600	184,800
48	72,900	52,500	74	267,200	192,400
49	77,600	55,900	75	278,200	200,300

2. METHOD FOR DETERMINING SIZE OF WOOD POLE REQUIRED

(a) *Formula Used.*

Given the span length, the size, material, number, and height of conductors, the size of pole which will fulfill the requirements of Orders 1240—b, 1242—b, 1280—c, and 1281 may be obtained by use of the following formulas for any transverse strength requirement as determined by hazards involved:

Let n_1 to n_n = number of conductors in groups, all conductors in a group being of the same outside diameter and at the same elevation.

N = total number of conductors.

P_1 to P_n = equivalent transverse forces in pounds per foot of span for the sizes of conductors in the respective groups, as taken from table 36.

h_1 to h_n = respective elevations above ground in feet, of conductors subjected to forces P_1 to P_n.

S = span length, in feet (or one-half the sum of the adjacent spans).

P_o = pressure in pounds per square foot as given in the rules mentioned above, according to local conditions (A, B, C, D or E).

D = estimated mean diameter of pole, in feet.

H = height of pole, above ground, in feet.

Then the moment due to the pressure on the pole is $M_p = \frac{1}{2} P_o D H^2$ pound-feet and the moment due to the pressure on the conductor is $M_c = S\,(P_1 n_1 h_1 + P_2 n_2 h_2 + \ldots P_n n_n h_n)$ pound-feet, and the total bending moment on the pole is $M = M_p + M_c$. This value of M will always be employed for poles carrying supply lines only, but where only signal conductors are concerned, the bending moment to be considered, in order to fulfill the requirements of Order 1281 will be as follows, when side guys are to be used:

$M = M_p + M_c$, when N is not greater than 10;

$M = M_p + \frac{10 M_c}{N}$, when N is 11, 12, 13 or 14; or

$M = M_p + \frac{2}{3} M_c$, when N is not less than 15.

When it is intended to use a pole strong enough to allow the omission of side guys, the bending moment to be considered will be $M = 2\,(M_p + M_c)$, or $M = 2\left(M_p + \frac{10 M_c}{N}\right)$, or $M = 2\,(M_p + \frac{2}{3} M_c)$, according to the value of N.

A pole should then be selected having a length equal to H plus the depth to which it is set in the ground, and a ground-line circumference given, by Table 37, a resisting moment equal to, or greater than, M as obtained from the above formulas.

(b) *Examples.*

(1) Suppose it is desired to choose a pole to comply with the orders under the following conditions:

Adjacent spans 61 feet 8 inches and 89 feet; average span 75.33 feet.

Height of pole above ground, 62 feet.

Line in urban territory, and carrying the following wire load:

Height of arm above ground	Size of Wire	Kind of Wire	Number of Wires	Voltage (or other class)
60.33	6 A. W. G.	T. B. W. P. solid copper	6	7.6 amp.
58.33	6 A. W. G.	T. B. W. P. solid copper	6	7.6 amp.
56.33	6 A. W. G.	T. B. W. P. solid copper	6	7.6 amp.
54.33	0000 A. W. G.	T. B. W. P. solid copper	4	2,300 volts
52.33	0000 A. W. G.	T. B. W. P. solid copper	4	2,300 volts
50.33	0000 A. W. G.	T. B. W. P. solid copper	6	2,300 volts
48.33	00 A. W. G.	T. B. W. P. solid copper	2	2,300 volts
44.33	350,000 c. m.	T. B. W. P. solid copper	4	2,300 volts
44.33	6 A. W. G.	T. B. W. P. solid copper	1	7.6 amp
42.33	6 A. W. G.	T. B. W. P. solid copper	2	110 volts

According to Order 1231—b, this pole will be required to comply with Grade C, and the transverse loading due to the wires will be computed as follows, the values of "Force per foot" being taken from column C of Table 36:

Span length in feet		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment (pound-feet)
75.33	×	.587	×	6	×	60.33	=	15960
75.33	×	.587	×	6	×	58.33	=	15420
75.33	×	.587	×	6	×	56.33	=	14900
75.33	×	.734	×	4	×	54.33	=	11980
75.33	×	.734	×	4	×	52.33	=	11520
75.33	×	.734	×	6	×	50.33	=	16620
75.33	×	.68	×	2	×	48.33	=	4950
75.33	×	.88	×	4	×	44.33	=	11720
75.33	×	.587	×	1	×	44.33	=	1960
75.33	×	.587	×	2	×	42.33	=	3740
						M_c	=	108770

Assume pole to be used will be one having an allowable fiber stress of 2,500 pounds per square inch. A pole of 57 inches ground-line circumference will have a resisting moment of 122000 pound-feet. The rules require a minimum top diameter of 6 inches, and for a pole of this size

$$M_p = \frac{1}{2} \times (\frac{2}{3} \times 8) \times \frac{6 + \frac{57}{3.14}}{2 \times 12} \times 62^2 = 10300 \text{ pound-feet,}$$

$$M = M_p + M_c = 10300 + 108800 = 119100 \text{ pound feet.}$$

(2) Suppose it is desired to determine whether or not the pole used complies with the orders, under the following conditions:

Adjacent spans 124.2 feet and 139.1 feet; average span 131.65 feet.

Height of pole above ground, 43 feet.

Western red cedar pole, of 10 inches top diameter, and 60 inches ground-line circumference.

Line crossing over railroad and carrying the following load:

Height of arm above ground in feet	Size of Wire	Kind of Wire	Number of Wires	Voltage (or other class)
45.5	¼ in.	Bare Str. steel	1	ground
42.17	0000 A. W. G.	T. B. W. P. Str. copper	3	13,000 volts
39.67	0000 A. W. G.	T. B. W. P. Str. copper	2	13,000 volts
37.17	0000 A. W. G.	T. B. W. P. Str. copper	4	13,000 volts
32.17	6 A. W. G.	T. B. W. P. Sol. copper	1	6.6 amp.
32.17	2 A. W. G.	T. B. W. P. Sol. copper	3	2,300 volts
28.17	10 A. W. G.	Bare Sol. copper	2	pvt. tel.

According to Order 1233—a, this pole will be required to comply with Grade A, and the transverse loading due to the wires will be computed as follows, the value of "Force per foot" being taken from column A of Table 36:

Span length in feet		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment (pound-feet)
131.65	×	1.25	×	1	×	45.5	=	7500
131.65	×	1.78	×	3	×	42.17	=	29600
131.65	×	1.78	×	2	×	39.67	=	18600
131.65	×	1.78	×	4	×	37.17	=	34800
131.65	×	1.32	×	1	×	32.17	=	5600
131.65	×	1.44	×	3	×	32.17	=	18300
131.65	×	1.10	×	2	×	28.17	=	8100
						M_c	=	122500

$$M_p = \tfrac{1}{2} \times \left(\frac{3}{2} \times 8\right) \times \frac{10 + \frac{60}{3.14}}{2 \times 12} \times 43^2 = 13400$$

$$M = M_p + M_c = 135900$$

By Table 37, the resisting moment for a ground-line circumference of 60 inches at a fiber stress of 2500 pounds per square inch is 142500 pound-feet. Since this is greater than M, this pole is strong enough to comply with the orders.

(3) Suppose it is desired to determine whether or not the pole and side guys used comply with the orders, under the following conditions:

Adjacent spans 104 feet 6 inches and 115 feet 6 inches; average span, 110 feet.

Height of pole above ground, 52 feet.

Chestnut pole of 8 inches top diameter, and 60 inches ground-line circumference.

Signal line crossing over railroad and carrying the following wire load:

Height of arm above ground in feet	Size of Wire	Kind of Wire	Number of Wires	Voltage (or other class)
51	8 B. W. G.	Bare copper	8	Signal
49	12 N. B. S.	Bare copper	10	Signal
47	12 N. B. S.	Bare copper	10	Signal
45	12 N. B. S.	Bare copper	10	Signal
43	12 N. B. S.	Bare copper	5	Signal

According to Order 1235—a, this pole will be required to comply with Grade D, and the transverse loading due to the wires will be computed as follows: the values of "Force per foot" being taken from column D of Table 36:

Span length in feet		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment (pound-feet)
110	×	.777	×	8	×	51	=	34900
110	×	.736	×	10	×	49	=	39700
110	×	.736	×	10	×	47	=	38100
110	×	.736	×	10	×	45	=	36500
110	×	.736	×	5	×	43	=	17400
						M_c	=	166600

$$M_p = \tfrac{1}{2} \times 8 \times \frac{8 + \frac{60}{3.14}}{2 \times 12} \times 52^2 = 12200$$

Since N is greater than 15, $M = M_p + \frac{2}{3} M_c = 12200 + 111065 = 123265$ pound-feet, if side guys are used, or twice this value, that is, 246530 pound-feet, if side guys are not used.

By Table 37, the resisting moment for a ground-line circumference of 60 inches and a fiber stress of 2500 pounds per square inch is 142500 pound-feet. Since this is less than the value of M to be used without side guys, the guys will be required, and they will be required to take the entire horizontal load.

By reference to Table 37 it will be seen that a pole slightly larger than 72 inches in ground-line circumference will be required if guys can not be installed.

Assume that guys are installed having a lead one-third of the height of attachment to the pole, or a lead of 15 feet with a height of attachment of 45 feet.

The force necessary at a height of 45 feet to produce—or to counteract—a bending moment of 123265 pound-feet at the ground line is $\frac{123265}{45} = 2740$ pounds, and the equivalent force acting in the direction of the guy will be $\frac{\sqrt{15^2 + 45^2}}{15} \times 2740 = 8660$ pounds. A guy will therefore be required having a tensile strength at least equal to $2 \times 8660 = 17320$ pounds.

4. Suppose it is desired to determine whether or not the pole used complies with the orders, under the following conditions:

Adjacent spans 104 feet and 92 feet; average span, 98 feet.

Height of pole above ground, 48 feet.

Chestnut pole, of 9 inches top diameter, and 58½ inches ground-line circumference.

Joint supply and signal line and carrying the following wire load:

Height of arm above ground in feet	Size of Wire	Kind of Wire	Number of Wires	Voltage (or other class)
47	6 A. W. G.	T. B. W. P. Sol. copper	6	6.6 amp.
45	6 A. W. G.	T. B. W. P. Sol. copper	6	6.6 amp.
43	0000 A. W. G.	T. B. W. P. Sol. copper	3	2,300 volts
43	00 A. W. G.	T. B. W. P. Sol. copper	3	2,300 volts
41	2 A. W. G.	T. B. W. P. Sol. copper	6	2,300 volts
39	2 A. W. G.	T. B. W. P. Sol. copper	3	230 volts
39	6 A. W. G.	T. B. W. P. Sol. copper	2	6.6 amp.
35	12 N. B. S.	Bare copper	10	Telephone
33	12 N. B. S.	Bare copper	8	Telephone

According to Order 1234—c, this pole will be required to comply with grade C, and the transverse loading due to the wires will be computed as follows, the values of "Force per foot" being taken from column C of Table 36:

	Span* length in feet		Force in lbs. per foot		Number of wires		Height above ground in feet		Bending moment in pound-feet
	98	×	.587	×	6	×	47	=	16250
	98	×	.587	×	6	×	45	=	15550
	98	×	.734	×	3	×	43	=	9280
	98	×	.68	×	3	×	43	=	8600
	98	×	.96	×	6	×	41	=	23100
	98	×	.96	×	3	×	39	=	11000
	98	×	.587	×	2	×	39	=	4490
½ ×	98	×	.491	×	10	×	35	=	8410
½ ×	98	×	.491	×	8	×	33	=	6350
							M_c	=	103030

$$M_p = \tfrac{1}{2} \times (\tfrac{2}{3} \times 8) \times \frac{9 + \frac{58.5}{3.14}}{2 \times 12} \times 48^2 = 7070$$

$$M = M_c + M_p = 110100$$

By Table 37 the resisting moment for a ground-line circumference of 58½ inches and a fiber stress of 2500 pounds per square inch is 132,000 pound-feet (by interpolation between 58 and 59 inches). Since this is greater than M, this pole is strong enough.

*Regarding the last two lines see also Order 1272-d.

3. ILLUSTRATION OF ALLOWABLE NUMBER OF WIRES ON A GIVEN POLE, AND ON A POLE SUPPORTED BY A GIVEN SIDE GUY

(a) *Assumptions on which Tables 38, 39 and 40 are based.* In Table 38 it is assumed (1) that all wire positions are filled and that crossarms are 2 feet apart; (2) that poles are set 5.5 feet in the ground; (3) that 6 pin crossarms are used unless otherwise stated; (4) that the placing of wires is begun at the top arm (wires 6 inches below the top of poles) and continues to lower crossarms until limited by strength of pole or clearance of wires above ground to a minimum of 19 feet at the support. This is assumed to be the minimum allowable clearance at the support if 18 feet clearance is to be maintained at the center of the span (see Table 3). Frequently a less number of crossarms is necessary where larger sags make the difference in elevation between the support and the center of span greater than 1 foot. (See Sag Tables 15, 16, 17, 24, 25, 26, and 27, Appendix A.)

In Tables 39 and 40 it is assumed (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, this 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 will be equivalent to that on one or more wires, depending on size and height of pole, and should be deducted in each case.

(b) *Use of Table 38.* The maximum number of wires which can be carried in compliance with these rules by sound chestnut, western red cedar, cypress and southern pine poles of different ground-line circumferences and different spans for a 35 foot pole, is given in Table 38, according to the hazards involved (A, B, or C).

The table may also be used for poles of greater height by using the ground-line circumference, but reducing the allowable number of wires, in proportion to the increase in elevation of the point of application of the load.

A taper of 2 inches per 5 linear feet is assumed in Table 38, but is used only for calculating the bending moment due to the

wind pressure on the pole itself; the pole strength is based entirely upon the ground-line circumference, assuming this to be the most stressed section.

TABLE 38—ALLOWABLE NUMBER OF NO. 4 SOLID COPPER T. B. W. P. WIRES TO BE CARRIED BY 35 FOOT SOUND CHESTNUT, WESTERN RED CEDAR, SOUTHERN PINE, AND CYPRESS POLES HAVING GROUND-LINE CIRCUMFERENCES OF FROM 32 TO 48 INCHES AND UNDER VARIOUS HAZARDS (A, B, OR C). (See foregoing explanatory note.)

Hazard	Span in Feet	Number of wires to be carried by pole having ground-line circumference of								
		32 in.	34 in.	36 in.	38 in.	40 in.	42 in.	44 in.	46 in.	48 in.
A	100	*	6	7	8	10	11	13	16	18
	125	*	4	5	6	8	9	10	12	14
	150	*	4	4	5	6	7	9	10	12
	200	*	3	3	4	5	5	6	7	9
B	100	*7	9	11	13	16	18	22	26	30
	125	*6	7	9	10	12	14	17	20	23
	150	*5	6	7	8	10	12	14	16	19
	200	*4	4	5	6	7	9	10	12	14
C	100	12	14	17	21	25	31	36	**40	**48
	125	9	11	14	16	20	23	28	33	36
	150	8	9	11	13	16	19	22	26	31
	200	6	7	8	10	12	14	16	19	22

(c) *Use of Tables 39 and 40.* The maximum number of wires which can be carried, in compliance with these orders, by poles supported by side guys of various strengths with various values of average span is given in Table 39 for supply lines (or for signal lines of grades A, B, and C), and in Table 40 for signal lines of grades D and E.

TABLE 39—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 CONDITIONS OF HAZARD (A, B, OR C). (See foregoing explanatory note.)

Hazard	Span in Feet	Number of the designated wires allowed with specified numbers and strengths of side guys.						
		1-4000 lb.	1-6000 lb.	1-10000 lb.	1-16000 lb.	2-10000 lb	1-10000 lb 1-16000 lb.	2-16000 lb.
A	75	6	9	15	24	31	40	49
	100	5	7	11	18	23	30	37
	125	4	6	9	15	18	24	29
	150	3	5	8	12	15	20	24
B	75	9	14	23	37	46	60	73
	100	7	10	17	27	34	45	55
	125	6	8	14	22	27	36	44
	150	5	7	11	18	23	30	37
C	75	14	21	34	55	69	89	.....
	100	10	15	26	41	52	67	83
	125	8	12	21	33	41	54	66
	150	7	10	17	28	34	45	55

*For Grade A 35-foot poles can not be used with so small a ground-line circumference, since pole top would be less than 7 inches. (See Order 1244—D.)

**These numbers of wires will require 8 pin crossarms.

TABLE 40—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 CONDITION OF HAZARD (D OR E). (See foregoing explanatory note.)

Hazard	Span in Feet	Number of the designated wires allowed with specified numbers and strengths of side guys.						
		1-4000 lb.	1-6000 lb.	1-10000 lb.	1-16000 lb.	2-10000 lb.	1-10000 lb. 1-16000 lb.	2-16000 lb.
D	75	16	24	41	65	81	.....	.....
	100	8	18	31	49	61	79	98
	125	7	10	24	39	49	63	78
	150	5	8	20	33	41	53	65
E	75	24	37	61	.....	.....	.....	.....
	100	18	27	46	73	92	.....	.....
	125	10	22	37	59	73	95	.....
	150	8	18	31	49	61	79	98

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, 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.

4. MINIMUM POLE SIZES AND RECOMMENDED DEPTH OF SETTINGS

(a) *Minimum Pole Sizes.* The dimensions of poles given in Tables 41, 42, and 43 are those referred to in Orders 1244—c and 1283—a, and are required under the conditions of loading specified by those orders. The dimensions are given for chestnut, western white cedar, red cedar, western cedar, Idaho cedar, and eastern or northern white cedar poles. Where other poles than these are used the dimensions required for any given grade of construction should be taken the same as poles having an equal ultimate fiber strength.

TABLE 41—MINIMUM DIMENSIONS OF CHESTNUT POLES
Sizes specified in Orders 1244—c and 1283—a.

Length of Pole in Feet	Minimum Circumference of Poles*					
	For grade D, with more than 40 signal wires (order 1283a) and for Grade A supply lines (order 1244c)		For grade D with 21 to 40 signal wires (order 1283a), for grade E, with more than 40 signal wires (order 1283a), and for grades B and C supply lines (order 1244c)		For grade D, with not more than 20 signal wires (order 1283a), and for grade E with not more than 40 signal wires order (1283a)	
	Circumference		Circumference		Circumference	
	At top	At 6 ft. from butt	At top	At 6 ft. from butt	At top	At 6 ft. from butt
	In.	In.	In.	In.	In.	In.
20	24	33	22	30	20	27
25	24	36	22	33	20	30
30	24	40	22	36	20	33
35	24	43	22	40	20	36
40	24	45	22	43	20	40
45	24	48	22	47	20	43
50	24	51	22	50	20	46
55	22	54	22	53	20	49
60	22	57	22	56	.....	.....
65	22	60	22	59	.....	.....
70	22	63	22	62	.....	.....
75	22	66	22	65	.....	.....
80	22	70	22	69	.....	.....
85	22	73	22	72	.....	.....
90	22	76	22	75	.....	.....

*These pole dimensions correspond to specifications for Class A, B and C poles, respectively, of the National Electric Light Association, American Telephone and Telegraph Co., and Western Union Telegraph Co.

TABLE 42—MINIMUM DIMENSIONS OF WESTERN WHITE CEDAR, RED CEDAR, WESTERN CEDAR AND IDAHO CEDAR POLES
Sizes specified in Orders 1244—c and 1283—a.

Length of Pole in Feet	Minimum Circumference of Poles*					
	For grade D, with more than 40 signal wires (order 1283a) and for Grade A supply lines (order 1244c)		For grade D with 21 to 40 signal wires (order 1283a), for grade E, with more than 40 signal wires (order 1283a), and for grades B and C supply lines (order 1244c)		For grade D, with not more than 20 signal wires (order 1283a), and for grade E with not more than 40 signal wires order 1283a)	
	Circumference		Circumference		Circumference	
	At top	At 6 ft. from butt	At top	At 6 ft. from butt	At top	At 6 ft. from butt
	In.	In.	In.	In.	In.	In.
20	28	30	25	28	22	26
25	28	34	25	31	22	28
30	28	37	25	34	22	30
35	28	40	25	36	22	32
40	28	43	25	38	22	34
45	28	45	25	40	22	36
50	28	47	25	42	22	38
55	28	49	25	44	22	40
60	28	52	25	46	22	41
65	28	54	25	48	22	43

*These pole dimensions correspond to specifications for Class A, B and C poles, respectively, of the National Electric Light Association, American Telephone and Telegraph Co., and Western Union Telegraph Co.

TABLE 43—MINIMUM DIMENSIONS OF EASTERN OR NORTHERN WHITE CEDAR POLES

Sizes specified in Orders 1244—c and 1283—a.

Length of Pole in Feet	Minimum Circumference of Poles*					
	For grade D, with more than 40 signal wires (order 1283a) and for Grade A supply lines (order 1244c)		For grade D with 21 to 40 signal wires (order 1283a), for grade E, with more tnan 40 signal wires (order 1283a), and for grades B and C supply lines (order 1244c)		For grade D, with not more than 20 signal wires (order 1283a), and for grade E with not more than 40 signal wires order 1283a)	
	Circumference		Circumference		Circumference	
	At top	At 6 ft. from butt	At top	At 6 ft. from butt	At top	At 6 ft. from butt
	In.	In.	In.	In.	In.	In.
20	24	33	22	29	18.75	27
25	24	36	22	32	18.75	30
30	24	40	22	36	18.75	33
35	24	43	22	38	18.75	36
40	24	47	22	43	18.75	40
45	24	50	22	47	18.75	43
50	24	53	22	50	18.75	46
55	24	56	22	53	18.75	49
60	24	59	22	56	.....	.....

*These pole dimensions correspond to specifications for Class A, B and C poles, respectively, of the National Electric Light Association, American Telephone and Telegraph Co., and Western Union Telegraph Co.

(b) *Recommended Depth of Setting of Poles.*

The values given in Table 44 are those recommended as the depths to which poles should be set under ordinary straight-line conditions in firm soil or rocks. On corners or angles or heavy dead ends these values should be increased by at least 6 inches. (See Orders 1217—d and 1283—a.)

TABLE 44—RECOMMENDED DEPTH OF SETTING OF POLES, ORDER 1283—A

Length of Pole in Feet	Setting in Soil	Setting in Rock
	Feet	Feet
20	5	3
25	5	3.5
30	5.5	3.5
35	6	4
40	6	4
45	6.5	4.5
50	7	4.5
55	7	5
60	7.5	5
65	8	6
70	8	6
75	8.5	6
80	9	6.5

5. DEPRECIATION OF WOOD POLES

Where a pole is required to conform to a definite grade of construction, A, B, or C, it must be maintained by being replaced or reinforced in accordance with Order 1244—b. The maximum allowable depreciation for grades A and B construction is one-third of the initial strength, and for grade C is one-half of the initial strength. Table 45 gives the minimum depreciated ground-line circumference and maximum allowable radial depreciation for wood poles of initial ground-line circumference from 24 to 75 inches, inclusive. These values are independent of the material of the pole.

Note: It is not advisable to use some kinds of poles without preservative butt treatment.

TABLE 45—DEPRECIATION OF WOOD POLES

Ground-line circumference when installed	Minimum depreciated ground-line circumference for		Maximum allowable radial depreciation for	
	Grades A and B	Grade C	Grades A and B	Grade C
In.	In.	In.	In.	In.
24	21.0	19.1	0.48	0.79
25	21.8	19.9	.50	.82
26	22.7	20.6	.52	.85
27	23.6	21.4	.54	.89
28	24.5	22.2	.56	.92
29	25.3	23.0	.58	.95
30	26.2	23.8	.60	.99
31	27.1	24.6	.62	1.02
32	28.0	25.4	.64	1.05
33	28.8	26.2	.66	1.08
34	29.7	27.0	.68	1.12
35	30.6	27.8	.70	1.15
36	31.5	28.6	.72	1.18
37	32.3	29.4	.74	1.21
38	33.2	30.2	.76	1.25
39	34.1	31.0	.78	1.28
40	34.9	31.8	.81	1.31
41	35.8	32.6	.82	1.34
42	36.7	33.3	.85	1.38
43	37.6	34.1	.87	1.41
44	38.4	34.9	.88	1.44
45	39.3	35.7	.91	1.48
46	40.2	36.5	.92	1.51
47	41.1	37.3	.95	1.54
48	41.9	38.1	.97	1.58
49	42.8	38.9	.99	1.61
50	43.7	39.7	1.01	1.64
51	44.6	40.5	1.03	1.67
52	45.4	41.3	1.05	1.71
53	46.3	42.1	1.07	1.74
54	47.2	42.9	1.09	1.77
55	48.1	43.7	1.11	1.80
56	48.9	44.5	1.13	1.84
57	49.8	45.3	1.15	1.87
58	50.7	46.0	1.17	1.90
59	51.5	46.8	1.19	1.94
60	52.4	47.6	1.21	1.97
61	53.3	48.4	1.23	2.00
62	54.2	49.2	1.25	2.03
63	55.0	50.0	1.27	2.07
64	55.9	50.8	1.29	2.10
65	56.8	51.6	1.31	2.13
66	57.7	52.4	1.33	2.17
67	58.5	53.2	1.35	2.20
68	59.4	54.0	1.37	2.23
69	60.3	54.8	1.39	2.26
70	61.2	55.6	1.41	2.30
71	62.0	56.4	1.43	2.33
72	62.9	57.2	1.45	2.36
73	63.8	58.0	1.47	2.40
74	64.7	58.7	1.49	2.43
75	65.5	59.5	1.51	2.46

PART 3

Electrical Utilization Equipment

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PART 3

Electrical Utilization Equipment

SECTION 130. SCOPE OF ORDERS

Order 1300. Equipment Accessible to Other Than Qualified Persons.

The following orders, Sections 130–139, inclusive, apply to all electrical utilization equipment, operating at voltages above 25 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: Signal equipment connected to signal lines and radio signaling apparatus is exempted, except from Section 139.

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 signaling system wiring.

Order 1301. Equipment Accessible to Qualified Persons Only.

Electrical utilization equipment, however, as well as generating equipment, if inclosed in a separate room or similar inclosed 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 131. GENERAL PROTECTIVE ARRANGEMENTS

Order 1310. Guarding Live Parts.

(a) *Equipment.*

(1) All ungrounded current-carrying parts of equipment operating at voltages higher than 100 volts to ground, shall be suitably guarded, if elevated less than 8 feet above floor or platform, or if exposed to contact above that level. (For signs see Order 1366—c-2.)

Exception: In locations where there are no exposed grounded surfaces within reach of persons when touching the parts under consideration and where none of the conditions listed as hazardous in Order 1312 exist, such parts operating at voltage less than 150 volts to ground are exempted from this order.

Note: See Orders 1100-1199 and Order 1354—a-1 for equipment located in inclosure accessible to qualified persons only.

(2) Where guards must at times be opened, thereby exposing live parts, they shall be of insulating material or so arranged that they cannot readily make contact with live parts while being removed.

(3) Where persons must at times enter inclosures while parts are alive, the guards shall be of insulating material unless removed 4 feet horizontally from all live parts.

(4) Under the conditions of (2) and (3) above, insulating mats or platforms shall be provided in locations having grounded floors.

(5) Such guards in locations subject to moisture shall be of the weather-proof type.

(6) Such guards in locations subject to corrosive vapors shall be constructed of materials and in such manner that they will resist corrosion under the particular conditions.

Note: Switches and fuses, except on switchboards, must be inclosed at any elevation. (See also orders 1350—h and 1351—d.)

(b) *Conductors.* (For wires in Elevator Shafts see Elevator Code Order 420.) (See also Order 1357—e.)

(1) All exposed conductors, not included in (2), (3) and (4) below, when brought closer to floor or platform than 8 feet, or when exposed to mechanical injury above that level, shall be guarded by inclosure in conduit, armored cable or surface metal raceways. (See also Section 133.)

Exception: (1) At small platforms erected subsequent to the installation of the wiring or where metallic conduit, armored cable or metal raceways are subject to rapid deterioration from excessive dampness

or other causes, open wiring may be inclosed by substantial wooden boxing, with an air space of one inch around the wires. Where boxing is used on vertical wires for part of the distance only, top of boxing shall be closed, and wires shall pass through holes bushed with approved non-absorptive, non-combustible insulating material.

(2) Trolley conductors and lightning arrester ground conductors are exempted from this order.

(2) All conductors in schools, theaters, assembly halls, hotels, hospitals and public garages shall be guarded by inclosure in rigid or flexible conduit, armored cable or surface metal raceways. (See also Order 1357—i-2 and Section 133.

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.

Note: (1) The 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 Code to include every building which accommodates more than two motor-driven vehicles.

(3) Conductors operating at voltages higher than 300 volts to ground shall be guarded by inclosure in conduit, in all buildings and at all elevations. (See also Order 1357—i.)

(4) Bus-bars and other open bare ungrounded conductors operating at voltages higher than 100 volts to ground, which are elevated less than 8 feet above floor or platform, shall be inclosed by suitable guards. (See also Order 1310—a-1 and Order 1358—b.)

(c) *Separation and Barriers.*

Bare parts at different potentials shall be effectively separated. Such parts in circuits of large capacity or which are operated at more than 300 volts shall, unless provided with the inclosure or other guard specified in (a) above, be provided with suitable barriers, if otherwise they would be liable to be short-circuited by tools or other conducting objects.

Order 1311. Working Space About Electrical Equipment.

(a) *General.* Suitable working space shall be provided and maintained about all electrical utilization equipment.

(b) *Minimum Dimensions.* The working spaces shall have minimum horizontal dimensions as follows:

(1) Equipment, operating above 150 volts to ground if on one side of working space, and no live or grounded parts on the other, 2.5 feet; if on both sides. 4 feet.

(2) Equipment, operating below 150 volts to ground, if on one side of working space and no live or grounded parts on the other, 1.5 feet; if on both sides, 2.5 feet.

(c) *Working Space Used as Passageway.*

Electrical utilization equipment shall not be placed adjacent to passageways or aisles, unless sufficiently removed therefrom that the above minimum working space dimensions may be maintained without encroaching on the passageway or aisles.

Order 1312. Where Explosives and Inflammables Exist. (See Appendix F.)

In locations where explosives, inflammable gas, or inflammable flyings normally exist in dangerous quantities, there shall be no exposed live parts. For enclosing live parts one or more of the following methods of protection shall be employed as may be required: (See also Order 1346—i.)

(1) When equipment is near inflammable material or when inflammable dust or flyings are present, casings of the inclosed type shall be used. All lamps shall be equipped with a vapor-tight globe and portable lamps with a substantial guard in addition. Wiring shall be in conduit, armored cable, or surface metal raceways.

(2) When equipment is located where explosive or inflammable vapors or gases exist in dangerous quantities, casings of the explosion-proof type shall be used; sockets and incandescent lamps shall be inclosed in vapor-tight globes, rigidly supported and wired with rubber-covered wire soldered directly to the circuit. Wiring shall be in rigid metal conduit and all fittings and outlets shall be electrically and mechanically continuous with the conduit and the conduit and fittings shall be sealed by effective means to prevent entrance of gases. Portable lamps shall not be used. (See also Order 1360—b-4.)

Order 1313. Grounding.

Grounding in accordance with methods set forth in Section 103 of Introductory Part is required for electrical utilization installations as follows:

(a) *Direct-Current Systems.*

(1) Three-wire direct-current systems operating at voltages less than 300 volts to ground shall always be grounded.

(2) Two-wire direct-current systems operating at voltages less than 300 volts to ground shall be grounded when the system is exposed to crosses from high-voltage lines.

(b) *Alternating-Current Systems.* (See diagram on page 308.)

(1) All secondary distribution systems operating at voltages less than 300 volts to ground shall be grounded.

Exception: Electrical furnace circuits are exempted from grounding requirements.

(2) Secondary distribution systems supplying lighting service shall be grounded at each service entrance. (See also Order 1031—b.)

(3) Secondary distribution systems supplying power service shall be grounded at the service entrance when the grounded conductor is extended to the service entrance and is necessary to supply service to the customer. (See also Order 1031—b.)

(4) Electrical utilities shall not make service connection from such systems to electrical utilization equipment unless the provisions of (1), (2) and (3) above have been complied with.

(c) *Noncurrent-Carrying Metal Parts.*

All exposed noncurrent-carrying metal parts of equipment operating at voltages above 100 volts to ground shall be bonded together and permanently and effectively grounded. (For signs see Order 1366—c-3.)

Exceptions: Grounding is not required for the following equipment:

(1) All equipment in locations where there are no exposed grounded surfaces within the reach of persons when touching the parts under consideration (normally elevated less than eight feet above the floor or distant less than five feet horizontally) and where none of the conditions listed as hazardous in Order 1312 exist, and provided the voltage at which the equipment operates is less than 150 volts to ground.

(2) All equipment accessible only to qualified persons, provided it is effectively insulated from ground, provided insulating mats, platforms or floors are present, on which qualified persons may stand, and provided there are no exposed grounded surfaces within reach of said qualified persons, at such times as said qualified persons may be in contact with any live part.

(3) Cases of toy and bell-ringing transformers, cases of meters operating at less than 750 volts to ground, portable lamps and household appliances such as toasters, percolators, vacuum cleaners, etc., cases of transformers used exclusively to supply current to switchboard instruments installed and guarded in all respects as required for the higher voltage to which they are connected and name plates on switchboards and other apparatus.

Note: (1) This order includes all such parts as frames of motors, cranes, cars, and switchboards, cases of transformers and switches, conduits, external metal parts of lighting fixtures, etc.

(2) The permanent grounding of frames of portable devices (especially in connection with voltages above 100 to ground, when the devices are used within 8 feet of the floor in locations such as bathrooms, laundries, etc., where persons may easily touch grounded surfaces at the same time as the device) may be obtained by the use of a three-wire portable cord with the portable device, one wire being used for the ground conductor and the connectors being properly designed so that wrong connections cannot be made by the user of the device.

(3) Where such grounding is difficult, as with lighting fixtures connected to knob-and-tube wiring, apparatus having external parts composed of non-absorbent, non-combustible insulating material is suggested.

Order 1314. Identification.

(a) *General.*

All electrical utilization equipment shall be suitably marked to indicate the voltage, capacity, intended use and other essentials for safe operation.

(b) *Polarity. Identification of Terminals.*

Unless sufficiently identified by position, the terminals of fixtures, lamp sockets and receptacles, plug receptacles and other outlet devices to which identified grounded conductors are to be attached, shall be composed of or plated with a white metal or alloy, such as zinc, nickel, silver, etc. (See also Orders 1340 and 1360—b-2.)

SECTION 132. SERVICE ENTRANCE—INCLUDING SWITCH, FUSES, METER. CHARACTER OF SERVICE AND PROTECTIVE DEVICES

Order 1320. Services. (For Theater Services see Order 1371.)

Each building shall have a separate service.

Exception: When this is impossible or impracticable, or in the case of buildings of private plants not on opposite sides of a highway they may be interconnected with yard wires.

Note: Industrial Lighting Code also calls for two services for factories, mills, offices and other work places. School Lighting Code makes similar requirement for school buildings of more than one story hereafter constructed. (See Appendices G and H.)

Order 1321. Construction Requirements for Overhead Service Wires.

(a) *Overhead Wires.*

(1) Service wires shall be so placed that moisture cannot form a cross connection between them.

(2) Service wires shall be kept clear of awnings, branches of trees, or other objects.

(3) Where service wires are attached to building they shall be supported by insulators of proper type for outside use.

Note: Where extra high voltage service wires (above 2500 volts) enter a building, the orders for Stations (Part I) and Lines (Part II) shall be complied with. (See also order 1325.)

(b) *Entrance Wires.*

(1) Service wires, operating at less than 750 volts, shall be enclosed in continuous rigid metal conduit, from the first support on the outside of the building to the main switch and fuses, and shall be run on the exterior of the wall to a point as close as practicable to the service switch required by Order 1324, except that the service conduit may be imbedded in tile, brick, concrete, masonry and similar non-inflammable materials.

Exception: Where service can be brought directly into the back of the main service cabinet, porcelain tubes slanting upward to the inside may be used.

(2) Conduit fittings equipped with non-combustible, non-absorptive insulating covers, with separate hole for each wire, slanting upward to the inside, shall be provided at the point of entrance of service wires.

(3) Entrance wires shall be so arranged as to prevent the entrance of water to the building.

(c) *Insulating Covering of Wires.* Service wires, operating at less than 750 volts, between the first support on the outside of the building and the main service cabinet shall have a rubber insulating cover; from the first support on the outside of the building to the supply line, they shall have a weather-proof insulating covering, except when run in conduit.

Order 1322. Construction Requirements for Underground Service Wires.

(a) *Protection of Service Wires.* Underground wires shall be insulated and protected against moisture and mechanical injury where brought into a building, and all combustible material shall be kept from the immediate vicinity.

(b) *Sealing Service Tubes Against Gas.* Where an underground service enters a building through tubes, the tubes shall be tightly closed at outlets with asphaltum or other nonconductor, to prevent gases from entering the building through such channels.

Note: Where extra high voltage service wires (above 2500 volts) enter a building, the orders for Stations (Part I) shall be complied with. (See also order 1325.)

Order 1323. Connection to Street Series Circuits and Trolley Systems.

(a) *Constant-Current Systems.* Constant-current systems shall not be run into buildings to supply utilization equipment.

(b) *Trolley Systems.* Trolley circuits having a ground return shall not be run into buildings to supply utilization equipment.

Exception: (1) Railway cars, car houses, passenger and freight stations connected with the operation of electric railway systems are exempted from this order.

(2) Circuits for power equipment in buildings of so-called fireproof construction, and for light and power equipment in isolated buildings used in the operation of quarries and similar places are exempted from this order.

Order 1324. Switches, Fuses and Circuit Breakers. (See also Orders 1350 and 1351.) (See diagram on page 308.)

At a readily accessible point of the basement or first floor and as close as practicable to the point where service conduit enters the building, there shall be installed a main switch to disconnect all service conductors and equipment and main fuses to protect all ungrounded service conductors (see also Order 1321—b-1).

Exception: (1) The switch blade may be omitted in any grounded conductor if other means is provided within the service cabinet for disconnecting such conductors.

(2) Where the service switch, service fuses and meter are combined in a self-contained device, or compact combination of such devices, having no exposed wiring or live parts and having all other parts protected by fuses, main fuses may be installed on the line side of service switch and meters need not be protected by service switches and fuses.

(3) Yard wires of private plants supplying more than one building not on opposite sides of the highway are not considered as service wires, so that fuses would not be required in each building, if there are other cut-outs, which afford proper protection, conveniently located on the mains.

(4) Where not more than four meters are required for different classes of service or separate customers in the same building, and

these meters are located adjacent to each other, the requirement of a main switch will be waived if each service has its own switch and fuses and may be disconnected independently of the other.

Order 1325. Services of 750-2500 Volts. (See also Order 1357—i.)

(a) *General.* In addition to complying with the other orders of this section in so far as they apply, service wires operating at from 750-2500 volts shall comply with these additional requirements.

Note: Where extra high voltage service wires (above 2500 volts) enter a building, the orders for Stations (Part I) shall be complied with.

(b) *Entrance Wires.* High-potential service wires preferably should enter the building underground, but in all cases the service conduit shall pass directly into the cabinet or enclosure containing the main switch and automatic protective devices (fuses, circuit-breakers, automatic oil break switches).

(c) *Oil Service Switch and Disconnecters.*

(1) The service switch shall be of the oil-immersed type and shall be so arranged that it can be disconnected from the supply lines by means of disconnecters or disconnecting pot-heads.

(2) If the service switch is of the automatic oil-immersed type no fuses or circuit-breakers need be installed on load side of switch.

SECTION 133. CONDUIT, METAL SURFACE RACEWAYS, ARMORED CABLE

(For Open Wiring and Concealed Knob and Tube Work see Order 1343.)

Order 1330. Installation of Conduit. (Rigid Metal Pipe.) (See also Orders 1310—b, 1312 and 1342.)

(a) *Minimum Size of Conduit.* Conduit smaller than one-half inch electrical trade size shall not be used.

(b) *Continuity Reaming and Supporting of Conduit.*

(1) Conduits shall be electrically and mechanically continuous from outlet to outlet or to junction boxes, cut-out boxes or cabinets.

(2) Conduits shall be reamed and properly coupled and secured to all fittings and the entire system shall be mechanically secured in position.

(c) *Elbows and Bends in Conduit.*

(1) All elbows or bends shall be so made that the conduit will not be injured; the radius of the curve of the inner edge of any elbow shall not be less than 3½ inches.

(2) Interior conduit shall have not more than the equivalent of four quarter bends from outlet to outlet.

(d) *Drainage of Conduit in Damp Places.*

Where there is probability of accumulation of water in conduit, due to condensation or other causes, the conduit shall be suitably drained or wires and cables shall be lead sheathed or have other covering designed to give equal or better protection.

(e) *Completion of Work.*

(1) Interior conduits shall be installed as a complete conduit system before the conductors are drawn in.

(2) Wires shall not be drawn in until all construction on that portion of the building has been completed.

(f) *Conduit Fittings.*

(1) All conduits shall be equipped at every outlet with an approved outlet box, plate, or other suitable conduit fitting. Outlet plates shall not be used where it is practicable to install outlet boxes. The box or plate shall be covered by a proper cover or fixture canopy. (See also Order 1346—1.)

(2) At exposed ends of conduit except at fixture outlets, where wires pass from the conduit system without splice, joint or tap, an approved fitting having separately bushed holes for each wire shall be used. (See also Order 1343—1-2.)

(3) All unused outlet openings in junction and outlet boxes, metal molding, conduit, etc., shall be effectively closed with metal which will afford protection substantially equivalent to that of the wall of the junction or outlet box, etc.

(g) *Placing Outlets for Concealed Work.*

(1) For concealed work in walls and ceilings composed of plaster on wooden joist or stud construction, outlet boxes or plates and also cabinets shall be so installed that the front edge will not be more than ¼ inch back of the finished surface of the plaster, and if this surface is broken or incomplete it shall be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or plate or of the cabinet.

(2) On wooden walls or ceilings outlet boxes or plates and cabinets shall be so installed that the front edge will be flush with the finished surface or project therefrom.

(3) Outlet boxes, junction boxes and plates shall be securely supported.

(h) *Protection of Wires at Outlets.* Metal conduits where they enter junction boxes, outlet boxes or wherever else they may terminate, shall be provided with proper terminal fittings, bushings or fastening plates fitted so as to protect wire from abrasion, except when such protection is obtained by the use of approved nipples, properly fitted in boxes or devices, or by the junction or outlet boxes themselves.

(i) *Accessibility of Cabinets and Junction Boxes.* Cabinets and junction boxes shall always be installed in such a manner as to be accessible. (See also Order 1353.)

Order 1331. Capacity of Conduits. (See also Order 1342.)

(a) *Number of Wires Permitted.* Wires installed in conduits shall conform to Tables 1, 2 and 2A. (See also App. C.)

Note: 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.

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								
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						

Exceptions to Table 1: 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 ¾ inch conduit and three No. 8 wires in a ¾ inch conduit.

TABLE 2—THREE-CONDUCTOR CONVERTIBLE SYSTEM

Size of Wires				Size Conduit Electrical Trade Size
two	14	and one	10	½ Inch
"	12	"	8	¾ "
"	10	"	6	1 "
"	8	"	4	1 "
"	6	"	2	1¼ "
"	5	"	1	1¼ "
"	4	"	0	1½ "
"	3	"	00	1½ "
"	2	"	000	1½ "
"	1	"	0000	2 "
"	0	"	250000	2 "
"	00	"	350000	2½ "
"	000	"	400000	2½ "
"	0000	"	550000	3 "
"	250000	"	600000	3 "
"	300000	"	800000	3 "
"	400000	"	1000000	3½ "
"	500000	"	1250000	4 "
"	600000	"	1500000	4 "
"	700000	"	1750000	4½ "
"	800000	"	2000000	4½ "

TABLE 2A—STAGE POCKET AND BORDER CIRCUITS, ELEVATOR CONTROL CIRCUITS, ETC.

(See also (b) below.)

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, see Appendix C.)

(b) *Wires of Different Systems.*

A conduit shall never contain circuits of different systems.

Order 1332. Installation of Armored Cables and Flexible Conduit. (See also Order 1342.)

(a) *Compliance with Other Orders.* Installation of armored cables and flexible conduit shall comply with the general requirements for conduits in so far as they apply and to these additional requirements:

(b) *Damp Locations.* In damp places or when laid in concrete, armored cable or flexible conduit shall have a lead covering placed between the outer braid of the wires and the steel armor.

(c) *Bends.* All bends shall be so made that armored cable or flexible conduit will not be injured.

Order 1333. Installation of Surface Metal Raceways. (See also Order 1342.)

(a) *Location.* Metal raceways may be used only for surface wiring in dry locations.

(b) *Continuity.* Metal raceways shall be continuous from outlet to outlet, to junction boxes, or approved fittings designed especially for use with metal raceways, and shall at all outlets be provided with approved terminal fittings which will protect the insulation of wires from abrasion, unless such protection is afforded by the construction of the boxes or fittings.

(c) *Where Passing Through Floors or Partitions.*

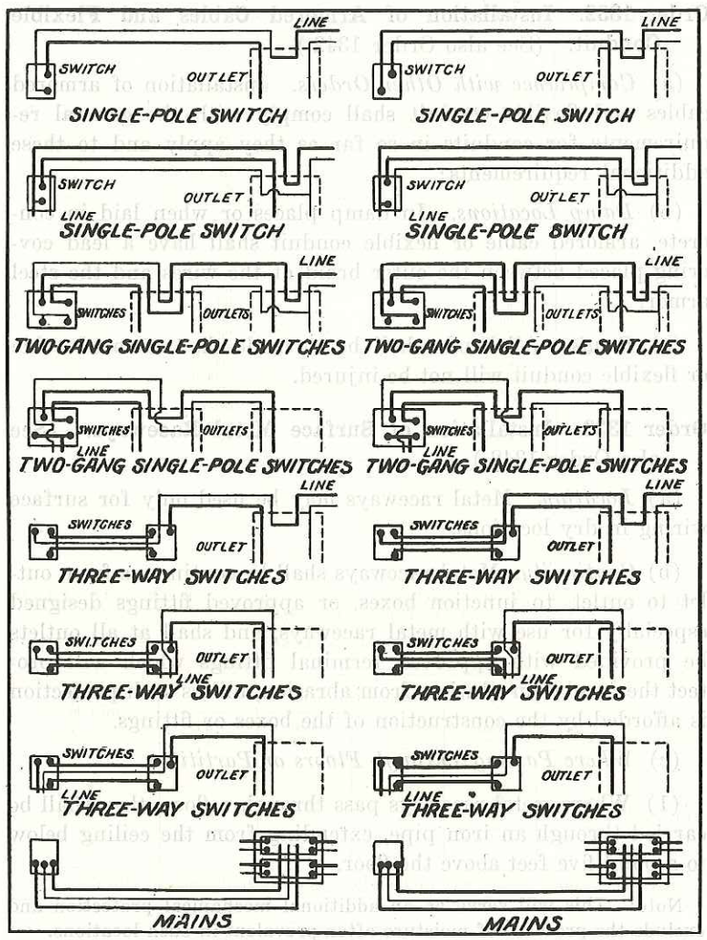
(1) Where metal raceways pass through a floor, they shall be carried through an iron pipe, extending from the ceiling below to a point five feet above the floor.

Note: This will serve as an additional mechanical protection and exclude the presence of moisture often prevalent in such locations.

Exception: Where the mechanical strength of the raceway itself is adequate this ruling may be modified to require the protecting piping from the ceiling below to a point at least three inches above the flooring.

(2) Where metal raceways pass through a partition, they shall be carried through an iron pipe extending three inches beyond the partition on each side.

DIAGRAMS ILLUSTRATING IDENTIFIED WIRING IN ACCORDANCE WITH ORDER 1340—A



DIAGRAMS ILLUSTRATING USE OF MARKED WIRES, ORDER 1340—A

Heavy lines indicate the black covered, ungrounded wire and light lines indicate the identified white covered grounded wire.

Sketches in the left column show the standard connections for marked wires of armored cables or twin wire; sketches in the right column show the standard connections for marked wires where single wire is used.

Cut furnished by courtesy of Underwriters' Laboratories.

Exception: Where such raceways pass through a partition the iron pipe required may be omitted and the raceway passed directly through, providing the partition is dry and the raceway is in a continuous length with no joint or coupling within the partition.

(d) *Screws and Bolts.* The heads of screws or bolts placed within the raceways shall be flush with the metal.

(e) *Number of Circuits.* Not more than four No. 14 A. W. G. rubber-covered wires, and no single circuit of more than 15 amperes shall be used in a metal raceway.

Order 1334. Wooden Raceways. Wooden raceways shall not be used except in accordance with Exceptions (1) and (2) of Order 1310—b-1.

SECTION 134. INSTALLATION AND PROTECTION OF WIRES FOR LIGHTING AND POWER SERVICE BELOW 750 VOLTS

(Signal wires and radio signaling apparatus are covered separately in Section 139.)

Order 1340. General.

(a) *Identification of Wires.*

(1) The grounded conductor of lighting circuits, from the service head to every terminal, and all grounding conductors of circuits and equipment shall have a continuous identifying outer covering, readily distinguishing such conductors from other conductors.

Exception: Such grounded conductors of existing installations and all such grounded conductors larger than No. 8 A. W. G. in size may be identified by another effective method, such as by means of tags.

(2) Identified grounded conductors of such lighting circuits shall be run without transposition throughout the entire installation and shall be properly connected at all fittings to identified terminals (see also Order 1314) in order to preserve continuity. The identifying covering of rubber-covered wire shall be white or natural gray.

Exception: Grounded conductors of fixtures, pendant and portable cords need not have continuous identifying outer covering, but shall be identified in another effective and ineradicable manner. (See also Order 1360—b-2.)

(3) Rubber-covered wire, except armored cable and on switchboards, having white or natural gray continuous identifying outer covering, shall not be used as ungrounded conductor.

(b) *Bare Wires.* (See also Order 1358—b-5 to 10.)

(1) Bare conductors shall be used only for switchboard, panelboard, or storage battery connections; or for electrolytic and low voltage welding circuits, and similar connections; or for trolley wires, third rails, crane runway wires, and other contact conductors and parts.

(2) Such bare conductors shall be fixed at adequate separations by the use of suitable supports.

(3) Except at the point where a permanent ground connection is made, such conductors within buildings shall be kept insulated from the ground.

(c) *Twin Wires.* Twin wires shall not be used except in conduits, armored cable, metal raceways, or flexible cords.

(d) *Avoidance of Excessive Inductance.* The two or more wires of an alternating-current circuit, if to be run in metal raceways or conduit, or other magnetic metal casing shall be installed within the same metal casing. The two or more wires shall not be run on opposite sides of I-beam or other iron or steel structures or in any manner so as to abnormally increase the inductance of the circuit.

Note: This should be done for direct-current systems, also, so that they may be changed to alternating current systems at any time, and because large self-inductance may cause fuses to blow explosively.

(e) *Splices and Connections.*

(1) Wires shall be so spliced or jointed as to be both mechanically and electrically secure without solder. The joints shall then be soldered, unless made with some form of approved splicing device, and then covered with an insulation equal to that on the wires.

Note: Rubber tape of proper thickness covered with adhesive tape ordinarily is used.

(2) Stranded wires shall be soldered before being fastened under clamps or binding screws, and whether stranded or solid, when No. 8 A. W. G. or larger they shall be soldered into lugs for all terminal connections, except where an approved solderless terminal connector is used.

(f) *Rheostat Connections.*

(1) Wherever insulated wire is used for connections between resistors and the contact device of a rheostat, the insulation shall be non-combustible or slow-burning.

(2) For large rheostats and similar resistances where the contact devices are not mounted upon 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 be mounted on noncombustible, nonabsorptive insulators, giving at least ½ inch separation from surface wired over, or where it is necessary to protect them from mechanical injury, each group of wires may be encased in flexible tubing and placed in conduit, the flexible tubing to extend at least one inch beyond the end of the conduit.

Order 1341. Carrying Capacities of Wires and Sizes of Wires Required.

(a) *General Table.*

The following tables (Tables 3 and 3-A), showing the allowable carrying capacity of copper wires and cables of 98 per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers, shall be followed in placing wires:

TABLE 3—ALLOWABLE CARRYING CAPACITIES OF COPPER WIRES

A. W. G. Number	Diameter of Solid Wire in Mils.	Area in Circular Mils.	Column A Rubber Insulation Amperes	Column B Varnished Cloth Insulation Amperes	Column C Other Insulation Amperes
18	40.3	1,624	3	.....	5
16	50.8	2,583	6	.....	10
14	64.1	4,107	15	.....	20
12	80.8	6,530	20	.....	25
10	101.9	10,380	25	.....	30
8	128.5	16,510	35	.....	50
6	162.0	26,250	50	60	70
5	181.9	33,100	55	65	80
4	204.3	41,740	70	85	90
3	229.4	52,630	80	95	100
2	257.6	66,370	90	110	125
1	289.3	83,690	100	120	150
0	325.0	105,500	125	150	200
00	364.8	133,100	150	180	225
000	409.6	167,800	175	210	275
.....	.....	200,000	200	240	300
0000	460.0	211,600	225	270	325
.....	.....	250,000	250	300	350
.....	.....	300,000	275	330	400
.....	.....	350,000	300	360	450
.....	.....	400,000	325	390	500
.....	.....	500,000	400	480	600
.....	.....	600,000	450	540	680
.....	.....	700,000	500	600	760
.....	.....	800,000	550	660	840
.....	.....	900,000	600	720	920
.....	.....	1,000,000	650	780	1,000
.....	.....	1,100,000	690	830	1,080
.....	.....	1,200,000	730	880	1,150
.....	.....	1,300,000	770	920	1,220
.....	.....	1,400,000	810	970	1,290
.....	.....	1,500,000	850	1,020	1,360
.....	.....	1,600,000	890	1,070	1,430
.....	.....	1,700,000	930	1,120	1,490
.....	.....	1,800,000	970	1,160	1,550
.....	.....	1,900,000	1,010	1,210	1,610
.....	.....	2,000,000	1,050	1,260	1,670

1 Mil.=0.001 inch.

Exception: Elevators, cranes, welders and other similar apparatus, which inherently is of such character as to require only intermittent service, may be wired in accordance with Table 6 of Appendix D.

Note: For insulated aluminum wire the safe carrying capacity is eighty-four per cent of that given in these tables for copper wire with the same kind of insulation.

TABLE 3-A—STANDARDIZED STRANDING

Strands			Cable		Allowable Carrying Capacities in Amperes		
No. of Strands	Mils Dia.	A. W. G No.	Area in Cir. Mils	Outside Dia. over Copper	Column A Rubber Insulation	Column B Varnished Cloth Insulation	Column C Other Insulation
7/ 25		22	4,490	.075	15	18	20
7/ 32		20	7,150	.096	20	25	25
7/ 40		18	11,370	.120	25	30	35
7/ 51		16	18,080	.153	35	40	50
7/ 64		14	28,740	.192	50	60	70
7/ 81		12	45,710	.253	70	85	90
7/ 91		11	58,000	.273	80	95	110
7/102		10	72,680	.306	90	110	130
19/ 64		14	78,030	.320	100	120	150
19/ 72		13	98,380	.360	125	150	175
19/ 81		12	124,900	.405	150	180	210
19/ 91		11	157,300	.455	175	210	250
19/107		*	217,500	.540	225	270	325
19/114		9	248,700	.570	250	300	350
37/ 91		11	306,400	.637	275	330	400
37/ 97		*	347,500	.679	300	360	450
37/102		10	381,200	.714	325	390	500
37/116		*	484,300	.798	400	480	600
61/102		10	633,300	.918	475	565	700
61/107		*	698,000	.963	500	600	750
61/114		9	798,300	1.030	550	660	825
61/121		*	893,100	1.090	600	720	900
61/128		8	1,007,000	1.150	650	780	1000
91/114		9	1,191,000	1.250	725	870	1125
91/128		8	1,502,000	1.410	850	1020	1350
127/114		9	1,660,000	1.480	900	1100	1460
127/128		8	2,097,000	1.660	1100	1300	1700

*These individual strands are odd sizes not listed in the American Wire Tables.

(b) *Minimum Size of Branch Circuit Wires.* Wires shall not be smaller than No. 14 A. W. G. except as allowed for fixture work, flexible cords, and signal work. (See g and h below and Order 1346—c). (For maximum connected load permitted on branch circuits see Order 1352—b.)

Note: Where wire sizes in these rules are specified it shall be understood that copper wire is referred to. If wire of other material is used, it shall have a carrying capacity equivalent to copper of the size specified.

(c) *Alternating Current Motor Circuits.* (See also Order 1352.)

(1) Conductors supplying current to one motor shall be of sufficient size to safely carry the starting current of the motor, but in no case shall the capacity be less than 110 per cent of the current rating of the motor. Where the branch circuit is protected by fuses, the rated capacity of the fuses shall not exceed the carrying capacity of the conductors as given in Tables 3 and 3-A, except that the carrying capacities of Column C, Tables 3

and 3-A, may be applied to rubber-covered wire to serve motors of a type of large starting current.

(2) Conductors in that part of the circuit leading from the motor running fuses or circuit breaker to the motor, are considered as being included in the protection afforded by such motor running overload protective device, even though such protective device be shunted or cut out of circuit during the starting period. The minimum size of the conductors in this portion of the circuit shall, therefore, be determined from Tables 3 and 3-A, applying to the kind of insulation used and in accordance with the rating of the fuses or setting of the circuit breaker provided for the running overload protection of the motor, except that in no case shall such conductors have a capacity less than 110 per cent of the motor rating.

(3) Conductors supplying a group of motors shall be of a size sufficient to carry the total load imposed upon them. Such conductors shall not be fused greater than 110 per cent of the rated carrying capacity of the wires, as given in Tables 3 and 3-A, pp. 194 and 195.

Note: (1) Conductor and fuse sizes for motors operating under normal conditions will be found in App. D.

(2) The total load referred to in above paragraph shall be that experienced under the most severe starting and operating conditions.

(3) This order applies only to the branch circuits up to the motor running overload protective device.

(d) *Direct Current Motor Circuits.* (See also Order 1352.)

(1) All conductors supplying current to a single motor shall have a current-carrying capacity sufficient to safely carry 110 per cent of the full load current without overfusing the wires. (See Tables 3 and 3-A above.)

(2) Conductors supplying a group of motors shall be of a size sufficient to carry the total load imposed upon them. Such conductors shall not be fused greater than the rated carrying capacity of the wires as given in Tables 3 and 3-A, pp. 194 and 195.

(e) *Trolley Wires.* Trolley or collector wires including crane runway wires shall be large enough to safely carry the current to be carried and to stand the strain put upon them when in use. (See also Order 1358—b-9.)

(f) *Neutral Wires.* (1) In three-wire direct current or single phase alternating-current systems the neutral shall be of

sufficient capacity to carry the maximum current to which it may be subjected.

(2) Such neutrals of branch circuits shall not be interconnected except at the center of distribution.

(g) *Fixture Wire.* Fixture wires shall not be smaller than No. 18 A. W. G. (See also Order 1346 and 1360—b.)

(h) *Flexible Cords.* Each conductor shall not be less than No. 18 A. W. G. (See also Order 1346.)

Order 1342. Wiring in Conduit Raceways and Armored Cable.

(For service entrances see Orders 1320 to 1325, inclusive.)

(a) *Conduit Wiring.* (See also Orders 1310—b, 1330, 1331 and 1357—g.)

(1) For conduit work wires shall have rubber insulating coverings, for all purposes, except that where excessive temperatures are present slow-burning insulation shall be used.

Exception: Varnished cloth insulation may be used in permanently dry locations for wires of No. 6 A. W. G. or larger.

(2) Within conduit, wires shall be without splices or taps.

(3) For conduit work, wires shall be double-braided for twin, twisted pair or multiple-conductor cables and for all single wires of No. 6 A. W. G. and larger.

(4) Where conduit is used to protect wires on or passing through side walls, the insulation of each wire shall be reinforced by approved flexible tubing extending from the insulator next below the conduit to insulator next above the conduit, unless the conduit is installed in accordance with Orders 1330 and 1331 and the wire is approved for conduit use. (See also Order 1343—i and l.)

(b) *Support of Vertical Conduit Wiring.*

(1) Wires in vertical conduit risers shall be supported within the conduit system in accordance with the following:

No. 14-A. W. G. to 0-A W. G. inclusive, every 100 feet.
No. 00-A. W. G. to 0000-A. W. G. inclusive, every 80 feet.
Above 0000-A. W. G. to 350,000-C. M. inclusive, every 60 feet.
Above 350,000-C. M. to 500,000-C. M. inclusive, every 50 feet.
Above 500,000-C. M. to 750,000-C. M. inclusive, every 40 feet.
Above 750,000-C. M. every 35 feet.

(2) Any of the following methods of support shall be used:

I. Approved clamping devices constructed of or employing insulating wedges inserted in the ends of conduits.

II. Junction boxes with covers inserted in the conduit system at the required intervals, in which insulating supports of approved type are installed and secured in a satisfactory manner so as to withstand the weight of the wires attached thereto.

III. Junction boxes with covers in which wires are supported on two or more insulating supports so placed that the conductors will be deflected at an angle of not less than 90 degrees, and carried a distance of not less than twice the diameter of the wire from its vertical position, and where necessary wires are additionally secured to these insulators by tie wires.

(c) *Wires Entering Cabinets.* Wires of No. 2 A. W. G. or larger shall not be deflected where they enter or leave cabinets, except in wiring gutters. (See also Order 1353.)

(d) *Surface-Wiring Metal-Raceways.* (See also Order 1333.)

(1) Wires shall have rubber insulating coverings, with at least one braid for wires smaller than No. 6 A. W. G. and two braids for wires No. 6 A. W. G. and larger and for twin wires.

(2) Wires shall be in continuous lengths from outlet to outlet, or from fitting to fitting with no joints or taps in the raceway.

(3) Where branch taps are necessary in wiring raceways, proper fittings for the purpose shall be used.

(4) Wires shall never be placed in metal raceways in damp locations, in concealed locations, or where the difference of potential between any two wires in the same system is over 300 volts.

(e) *Armored Cable.* (See also Order 1332.)

Wires shall have rubber insulating covering meeting the requirements for rubber-covered wires or cords of the specified types, and construction.

Order 1343. Open Wiring and Concealed Knob and Tube Work. (For Crane Collector Wires see Order 1358; for Trolley Wires see Order 1345.)

(a) *Insulation of Wires.*

(1) Wires for open work in dry places shall have rubber, slow-burning weatherproof, varnished cloth or slow-burning insulating coverings. When especially subject to acid fumes or corrosive vapors, either slow-burning weatherproof, varnished cloth or rubber insulating coverings shall be used.

(2) Wires for concealed work or in damp places shall have rubber insulating covering which shall be double braided for wires No. 6 A. W. G. and larger.

(b) *Wires in Plaster, etc.* Wires shall not be laid directly in plaster, cement or similar materials.

(c) *Wires in Attic.* Wires in unfinished attics or roof spaces shall not be run on knobs or cleats on upper edges of joists.

(d) *Support of Wires in Open Work.*

(1) Wires shall be rigidly supported on non-combustible, non-absorptive insulators, which will separate wires from each other and from the surface wired over in accordance with the following table:

Voltage	Distance from Surface	Distance Between Wires
0-300	In dry places.....½ inch	2½ inches
0-300	In damp placesor where subject to corrosive vapors.1 inch	2½ inches
300-750	.....1 inch	4 inches

(2) Where wiring over flat surfaces, wires shall be supported at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports shall be shortened. In buildings of mill and similar construction, mains of not less than No. 8 A. W. G., where not liable to be disturbed, may be separated about six inches and supported at each timber only, but the maximum span shall not exceed 8 feet.

(3) Wires for open work dead-ended at a rosette, socket or receptacle shall have a support within twelve inches of the same.

(4) Wires crossing overhead floor timbers in rooms where they may be exposed to injury, shall be attached by their insulating supports to the under side of a wooden strip not less than one-half inch in thickness, and six inches in width.

Note: Instead of such wooden strips, guard strips of wood not less than seven-eighths inch thick may be used on each side close to wire, but not closer than one inch, and of sufficient depth to provide suitable protection.

(5) 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.

(e) *Support of Wires in Concealed Work.*

(1) Wires for concealed work shall be rigidly supported on non-combustible, non-absorptive insulators which are not more

than four and one-half feet apart, and which remove the wire at least one inch from the surface wired over.

(2) Wires shall be kept at least five inches apart.

Note: It is strongly recommended that wires be run on separate timbers.

(3) Split knobs may be used for wires of No. 10 A. W. G. and smaller only.

(f) *Tying of Wires.*

(1) Wires of No. 8 A. W. G. or larger used with solid knobs shall be securely tied thereto with wires which have an insulation of the same type as that of the wires tied.

(2) Tie wire shall be of same size as wire tied, except that it need not exceed No. 6 A. W. G. in size.

(g) *Fastening of Knobs and Cleats.* Knobs or cleats, which are arranged to grip the wire, shall be fastened by screws, or barbed or cement-coated nails with leather washers. If nails are used, they shall penetrate the wood for a distance of at least one-half the depth of the knob or cleat.

(h) *Flexible Tubing.*

(1) Wires at distributing centers, meters, switches, or other places where space is limited and the proper separation of wires cannot be maintained, or when fished shall be separately encased in a continuous length of flexible tubing, extending from support to support. (See also 1-1 below.)

(2) At all outlets in concealed knob-and-tube work the flexible tubing shall extend from the last non-combustible, non-absorbent insulating support into and be secured to the outlet boxes or plates required by (m) below.

(3) In the case of combination gas and electric outlets, the tubing on the wires shall extend at least flush with the lower end of gas caps.

(4) Wires may be fished only in places where suitable inspection can be made to assure that the work is in compliance with this code.

(i) *Wires Passing Through Walls and Floors.*

(1) Wires in open work shall be separated from contact with walls, floors, timber or partitions through which they may pass by non-combustible, non-absorptive insulating tubes, such as porcelain or glass, except at outlets where approved flexible tubing is required. (See h-2 above.) Such bushings shall be long

enough to bush the entire length of the hole in one continuous piece. (See also Order 1342—a-4.)

(2) Wires for concealed work shall be separated from walls, floors, timbers, and partitions, through which they may pass by non-combustible, non-absorptive insulating tubes, such as porcelain or glass. Wires passing through cross timbers in plastered partitions shall be protected by an additional tube, extending at least four inches above the timber.

(j) *Clearance from Other Wires or Pipes.*

(1) Wires of any circuit coming within two inches of other light, power or signal circuits, shall be permanently separated therefrom by a continuous and firmly secured, non-conducting material in addition to the insulation on the wires. (See also Order 1391—j.)

(2) Wires crossing pipes shall be protected in the same manner as called for in paragraph (1) above.

(3) Wires crossing pipes in wet places shall be protected as called for in paragraph (1) above, and in addition shall be kept at least two inches from such pipes.

Note: It is better to run wires over pipes upon which moisture is likely to gather, or which by leaking might cause trouble on a circuit.

(k) *Wires Entering Cabinets, etc.* Where entering cabinets, cut-out boxes or junction boxes, except where they are in conduit, armored cable or metal raceways, wires shall be protected by non-combustible, non-absorptive insulating bushings which fit tightly into the holes in the box or cabinet and are well secured in place. Not more than one conductor may enter through one bushing.

Note: The wires should completely fill the holes in the bushings so as to keep out dust, tape being used to build up the wires if necessary.

(l) *Mixed Work.*

(1) When, in concealed knob-and-tube work, it is impracticable to place the whole of a circuit on non-absorptive, non-combustible insulating supports, that portion of the circuit which can not be so supported shall be installed with metal conduit or armored cable, except that if the difference of potential between the wires is not over 300 volts and wires are not exposed to moisture, they may be fished when separately encased in flexible tubing, extending in continuous lengths from support to support, from support to outlet, or from outlet to outlet.

(2) When using either conduit or armored cable in mixed concealed knob-and-tube work, the requirements for conduit work or

armored cable work shall be complied with as the case may be. Proper fittings having a separate bushed hole for each wire shall be used for terminating the conduit or armored cable. (See also Order 1330—f-2.)

(m) *Outlet Boxes or Plates and Fixture Studs Required.* (See also Order 1360—c.)

(1) Outlet boxes or plates shall be installed at all outlets in concealed knob-and-tube wiring for lighting. Outlet plates shall not be installed where it is practicable to install outlet boxes. The box or plate shall be covered by a proper cover or fixture canopy. (See also Order 1346—1.)

Note: In order that bracket lights having flat backs or canopies may be used, it is strongly recommended that outlet boxes having a depth of at least 1½ inches and a maximum opening in plastered surface of wall of 3 inches. (See also Order 1360—c-2.)

(2) Adequate supports for fixtures shall be installed at all straight electric lighting outlets. (See also Order 1360—c-5.)

(3) At outlets for combination gas and electric fixtures gas pipes shall be fastened to boxes or plates so as to secure good electrical contact.

(4) Outlet boxes and plates shall be supported as required by Order 1330—g.

(n) *Broken Surface at Outlets.* When the surface at any outlet is broken, all holes or open spaces shall be repaired.

Order 1344. Insulation Requirements for Wiring.

The wiring of an installation shall comply with the following requirements:

(1) The complete installation and any portion thereof with all cut-outs and safety devices in place, shall have a resistance between wires and between all wires and the ground (not including attachments, sockets, receptacles, etc.) not less than that given in the following table:

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	12,500 ohms

(2) When the lamp sockets, receptacles, electroliers, etc., are also connected, one-half of the resistance specified in the table will be required.

Order 1345. Wiring of Car Houses and Car Storage Yards.

(a) *Trolley Wires.*

(1) The trolley wires shall be securely supported on suitable insulating hangers, designed for the voltage used, and shall be placed at such a distance apart that the distance between any two hangers is less than the distance from the trolley wire to the floor or rail.

(2) Wood troughing or sufficient protection to prevent trolley pole forming a contact with any metal part of the building shall be provided.

(b) *Cut-Out Switch and Line Breakers.*

(1) An emergency cut-out switch in an accessible location outside of the building, arranged so that all trolley wires in the building may be cut at one point, shall be provided. Line insulators shall be installed so that when the emergency switch is open, the trolley wire leading into the building will be dead at all points, within at least 50 feet of the buildings. In car houses not used as operating stations, the current shall be cut out of the building when not needed for use in the building.

(2) Trolley wires in car storage yards, or distinctive sections of a large storage yard shall be controlled by an emergency cut-out switch, as described above. Yards in conjunction with car houses shall be treated as a separate section and have auxiliary cut-out switch.

(3) When car house or car storage yard is divided into fire sections auxiliary cut-out switches shall be arranged to control each section independently and may be located inside of building near track entrance.

(c) *Lightning Arresters.* Approved lightning arresters shall be installed to adequately protect all overhead trolley wires in car houses and car storage yards inside of the line insulators (breakers).

(d) *Current Collectors to Be Disconnected.* Current collectors shall be removed from contact with trolley wires when cars are not in use.

Note: Suitable signs should be posted in conspicuous places, ordering this done.

(e) *Bonding of Rails.* All rails shall be bonded at each joint with a conductor having a carrying capacity at least equivalent to No. 0-A. W. G. annealed copper wire, and all rails shall be

connected to the outside ground return circuit by not less than No. 0-A. W. G. copper wire, or by equivalent bonding through the track.

(f) *Third Rails.*

(1) Power third rails shall be rigidly supported on suitable insulating supports and properly bonded at joints.

(2) Power rails within each fire section of building or storage yard shall be controlled by an emergency cut-out switch located in a readily accessible place outside of buildings.

(g) *Control of Lamps and Stationary Motors.* All lamps and stationary motors shall be installed in such a way that one main switch controls the whole of such installation, lighting and power, independently of cut-out switch called for in (b) above.

(h) *Wiring of Apparatus.*

(1) All wiring and apparatus shall be installed in accordance with the orders of the other sections of this code.

(2) When current for lighting, stationary motors, heating, testing apparatus, etc., is from a grounded trolley circuit, the following special rules shall apply:

I. Voltage for light, heat, or power shall not exceed 750 volts.

II. Approved cut-outs and switches shall be placed in the non-grounded side of light and motor circuits they are to protect. Light circuits shall not have more than 2000 watts, depending upon a single cut-out.

III. Drops to lights shall be flexible rubber-covered wire or packing-house cable.

IV. In series systems sockets shall be of the weatherproof or porcelain keyless type and of a voltage rating for the current used.

V. The main ground, or return wire, shall connect with the rails or negative feeder at not less than two places and shall be protected against mechanical injury.

VI. All cut-outs and switches in grounded systems shall be installed in cabinets of non-conducting material. If wooden cabinets are used, they shall be lined with ¼ inch fire-resisting insulating material and painted with a non-conducting paint.

VII. All portable testing, lighting and power devices and all pendant cords and portable conductors shall be constructed to withstand hard usage.

VIII. Controlling devices and apparatus for feeder distribution systems for outside distribution shall be installed in a fire-resisting room or compartment.

Order 1346. Use of Portables and Pendants. (See also Orders 1341—g and h and 1360—a.)

(a) *Show Windows.* Portable cords shall not be used in show windows or in show cases, unless provided with metal armor.

Exception: Portable cord may be used for the purpose of supplying current to portable lamps and other devices for exhibition purposes.

(b) *Voltage Limit.* Portable and pendant conductors, except in electric railway property, shall not be used where the voltage between wires is over 300 volts.

Exception: Portable cords for portable or movable motors for grinding and other uses, operating between 300 and 500 volts to ground may be used if the following construction requirements are complied with:

(1) The insulation on portable cords shall be at least 3/64 inch in thickness and the size shall not exceed No. 8 A. W. G. unless flexible cord of the reinforced steel armored type is used.

(2) Steel armor of portable cord and all other exposed non-current-carrying parts shall be grounded in accordance with requirements for grounding of section 103, Introductory Part.

(3) There shall be no exposed live parts of wall receptacles, and such receptacles shall be located at least 5 feet above the floor. Floor receptacles shall not be used.

(4) Wall receptacles shall be of a distinctive type not interchangeable with ordinary wall receptacles of the lighting system.

(5) Plug connectors shall be arranged so that they can be inserted in receptacle in one position only, thereby insuring against wrong connection of ground required above.

(c) *Use of Flexible Cords.* (For Garages see Order 1382.)

(1) The use of flexible cords shall be limited to wiring of pendants (see also Order 1360—g), such as single lamps (not clusters), portable equipment and chain fixtures.

(2) Flexible cord shall not be hung on or fastened with or come in contact with nails, staples, hooks, pipes, machinery or other metal supports.

(3) Flexible cords for pendants in dry places, where not subject to hard usage, may be cotton or silk covered twisted or parallel lamp cord, but where subject to hard usage shall be reinforced, armored or other similar heavy duty cord.

(4) Flexible cords for pendants in damp places shall be brewery, canvasite or other similar heavy duty water-proofed cords.

(d) *Cord for Portable Equipment.* (For Garages see Order 1382.)

(1) Flexible cords for portable equipment in dry places shall meet the requirements of order (c-3) above.

(2) Flexible cords for such equipment in damp places shall be reinforced weather-proof, packing house, armored reinforced weather-proof or other similar heavy duty water-proofed cords.

(3) Flexible cords for theater stages and borders shall be stage cable having cotton weather-proof covering on each conductor and two cotton weather-proof outer coverings.

(4) Flexible cord for elevator lighting and control shall be special elevator cable, approved for this service.

(e) *Strain at Connections.* Portable and pendant conductors shall be so installed that no strain can be placed on the terminal connections and shall have no joints except at suitable fittings.

(f) *Use of Fixed Receptacles for Portables.* Where portable conductors are required, fixed sockets or receptacles shall be provided at safely accessible points with the more exposed conducting part attached, where practicable, to the grounded side of the circuit, and so located that liability of such conductors being brought into dangerous proximity with other live parts will be reduced as far as practicable. (See also Order 1111—b-2, Section 111 of Part I, and Order 1360—d-10.)

(g) *Connectors for Portable Cords.* Connectors which disconnect all poles from the live source of energy by a single operation shall be used.

(h) *Guarding Live Parts of Connectors.*

(1) Connectors shall be so constructed (with guards when necessary) that the person using them cannot inadvertently come in contact with live parts, or be burned by arcing, when interrupting the circuit.

(2) The ends of a separable connector which are left alive shall have live parts suitably guarded.

(i) *Connectors in Hazardous Locations.* Where connectors are exposed to inflammable gas or flyings they shall be so arranged as not to be exposed to accidental opening by persons handling portable conductors or devices.

(j) *Design for Separable Connectors.* Separable connectors shall be so designed that the plugs will not fit receptacles rated for larger currents than the plugs, and shall be of the polarity type.

(k) *Protection of Cord at Sockets.*

If the socket is not attached to a fixture, the inlet shall be equipped with an insulating bushing, which if threaded shall be

not 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.

Note: It is recommended that bushings having holes $\frac{9}{32}$ inch in diameter be employed with plain pendant cord and holes $\frac{13}{32}$ inch in diameter with reinforced cord.

(l) *Protection of Cord at Outlet Boxes.* Where passing through covers of outlet boxes, flexible cords shall be protected by bushings especially designed for this purpose, or the cover must be provided with a smooth, well-rounded surface on which the cord will bear. So-called hard rubber or composition bushings may not be used.

(m) *Portable Electric Hand Lamps.* Portable electric hand lamps shall be equipped with a keyless socket of non-combustible, non-absorbent insulating material, large handle of non-absorbent insulating material (such as impregnated wood), basket guard, reflector and proper cord. (See d above and Order 2114 Industrial Lighting Code.)

SECTION 135. SWITCHES, FUSES, CIRCUIT-BREAKERS, CABINETS, SWITCHBOARDS, CONTROLLERS, TRANSFORMERS, MOTORS, GENERATORS, CRANES

Order 1350. General Requirements for Switches.

(a) *Where Switches Are Required.*

(1) Suitable switches shall be installed in all circuits to lamps, motors, transformers, storage batteries, welders, furnaces and similar utilization equipment to make possible the independent disconnection of all such equipment from the source of supply.

Exceptions. (1) Parts or pieces of utilization equipment intended to operate as a unit, as, for instance, a motor and its starting device, may be controlled by one switch.

(2) An automatic circuit-breaker complying with Order 1351—f-3 may serve as a switch for motors if it disconnects all ungrounded wires of the circuit.

(3) Utilization equipment may be disconnected by plug connectors, arranged as required by Order 1346-g-h-i- and j.

(4) A group of incandescent lamps on the same branch circuit may be disconnected by one switch. (See also Order 1352—b.)

(2) Switches shall be so placed in motor circuits that each motor and its starting device may be disconnected from the source of supply.

Exception: One switch may serve to disconnect several motors and their starters from the source of supply, if within sight of the several motor starters it serves.

Note: If a branch circuit has connected to it only one motor and its starter, the above switch may be installed on the distribution panel board. Moreover, it may be of the open-knife type, provided, the cabinet or enclosure is locked and accessible only to qualified persons.

(3) Switches shall be so placed in feeder conductors supplying panel boards that each panel board may be independently disconnected from the source of supply.

Exceptions: (1) Such switches will not be required if the panel boards are equipped with switches for disconnecting individual branch circuits or groups of branch circuits from their supply circuit. (See also Order 1351—d.)

(2) If the installation comprises only one panel board, the service switch may serve as the disconnecting switch for the panel board.

Note: Two panel boards placed adjacent to each other will be considered the same as a single panel board.

(3) Panel boards supplying emergency lighting (stair and exit lights) are exempted.

Note: It is not desirable to subdivide control of the wiring for emergency lighting.

(4) Switches shall be provided as necessary to make possible the disconnection of all fuses from the source of electrical supply before being handled.

Exception: It will not be required that such switches be located within sight of the fuses to be disconnected from the source of supply.

Note: Switches installed in accordance with Order 1324, subdivisions a-1, a-2, a-3 above and subdivisions d-1 and d-2 of Order 1351, provide in general a satisfactory arrangement to meet this requirement.

(5) Switches or plug connectors shall be installed to permit the disconnection of temporary wiring or portable conductors from permanent or fixed wiring.

(b) *Switches to Be Readily Accessible.*

(1) All switches shall be readily and safely accessible and shall be installed in such a manner as to minimize the danger of accidental operation.

(2) Manual starters for motors or the manually operated part of any motor controller shall be within sight of equipment controlled. Manually operated parts of switches for heaters and furnaces shall be within sight of the equipment such device controls. (See i below.)

Note: General Safety Order 3 requires all machines, not individually motor driven, to be equipped with a loose pulley or a clutch or some other adequate means of stopping the machinery quickly. This has been interpreted to mean that the stopping device must be within easy reach of the machine operator when operator is in his or her working position. Although individually motor-driven machines are exempted from this requirement, it is strongly recommended that the starting and stopping device of new or reconstructed electrically driven machinery be located in accordance with Order 3, so that in the event it later becomes necessary to include such equipment under Order 3, it will not be necessary to make changes for this reason.

(c) *Switches to Be Indicating.* 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.

(d) *Number of Conductors to Be Disconnected.* (See also Orders 1324 and 1365—d.)

(1) Switches required by (a) above shall open all ungrounded conductors of circuits supplying current to utilization equipment.

Exception: Single pole switches will be permitted in two-wire ungrounded lighting branch circuits.

(2) Single pole switches and three-way and four-way switches, which shall be classed as single pole switches, shall be placed in the ungrounded conductors.

Note: This order forbids the so-called "live-line" wiring scheme for three-way switches.

(e) *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.

(2) If switches are not capable of breaking 150 per cent of the full load current as required above, they shall be so constructed that they may be locked in the closed position, or they shall be so located that they are not accessible to other than qualified persons.

(f) *Motor Starting Switches.*

(1) Where a switch is used to shunt the fuses or other motor protective devices during the starting period, it shall be of such type that it will be held in off and running positions, but cannot be left in the starting position without the proper running overload protective devices in circuit.

(2) When the disconnecting switch required by (a-2) 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, in accordance with Order 1357—f.

Exception: Motors of one-fourth horse power or less need not have their starters so equipped.

(g) *Switches for Temporary Wiring.* (See Order 1350—a-5.)

(h) *Guarding Live Parts of Switches.* (See also Orders 1310, 1351—d and 1354.)

All manual switches, including service entrance switches, shall have suitable casings or inclosures of such design as to permit of operation without opening the inclosure and so that the operator is at all times protected against danger. Cases shall be locked, sealed or made inaccessible, to other than qualified persons, by other suitable methods.

Exception: Switches on switchboards and panelboards which are guarded as required by Order 1310, are exempted from this order. Panelboards complying with order 1354—b need not be installed in locked cabinets. Single-pole, three-way and four-way switches for use in two-wire branch circuits are not included under this order.

(i) *Locking of Switches.* 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.

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.)

(j) *Disconnecters.* Disconnecters shall be accessible only to properly qualified persons. They shall also be protected by signs warning against opening the disconnectors while carrying current.

(k) *Switch Blades to Be Dead.* Where practicable, switches shall be so wired that blades will be dead when switch is open.

(l) *Contact and Blade Requirements.*

(1) Switches shall be so constructed as to make and maintain good contact.

(2) Knife switches shall maintain such alignment under service conditions that they may be closed with a single unhesitating motion.

Note: Quick make and quick break switches are strongly recommended.

(m) *Clearances and Arrangement.*

(1) Where a number of switches are installed in one location, they shall be grouped in an orderly manner.

(2) When in cabinets, live metal parts shall have clearances from metal walls and doors as specified in Order 1353.

(3) Single-throw knife switches shall be so placed that gravity will not tend to close them.

(4) Double-throw knife switches when mounted in the vertical position shall have a locking device so constructed as to insure the blades remaining in the open position when so set.

Note: Up to 250 volts and thirty amperes, indicating snap or push switches are recommended in preference to knife switches on lighting circuits. (See also Order 1354—b.)

(n) *Flush Switches—(Snap or Push).* Where flush switches or receptacles are used, whether with conduit or not, they shall be inclosed in a box constructed of iron or steel, in addition to the porcelain enclosure of the switch or receptacle.

(o) *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.

(p) *Sub-bases for Snap Switches in Open Wiring.* Sub-bases of non-combustible, non-absorptive insulating materials, which will separate the wires at least ½ inch from the surface wired over, shall be installed under all snap switches used in exposed knob and cleat work. Sub-bases shall also be used in metal raceway work, but they may be made of hardwood or they may be omitted if the switch is approved for mounting directly on the metal raceway.

(q) *Time Switches.* Time switches, sign flashers and similar appliances shall be of approved design and inclosed in approved cabinets, except sign flashers on or within the body of structure of the sign, in which case they shall be in separate, completely in-

closed, accessible weather-proof boxes or cabinets of metal, of thickness not less than that of the metal of the sign itself.

(r) *Compliance with Other Orders.*

1. *Cranes.* For additional requirements for switch installations for cranes not covered in this section, see Order 1358.

2. *Outline Lighting and Signs.* Switch installations for outline lighting and signs shall conform to the requirements of Orders 1365—d and 1366—a, in addition.

3. *Service Entrance Switches.* For additional requirements see Orders 1324 and 1325.

Order 1351. General Requirements for Fuses and Circuit-Breakers. (See also Order 1352.)

(a) *Where Fuses and Circuit-Breakers Are Required.*

(1) Fuses or circuit-breakers shall be provided in all circuits to protect all ungrounded conductors.

(2) Two-wire branch circuits shall be protected by a fuse or circuit-breaker in each conductor.

Exception: On systems having a grounded neutral or having one side grounded and where the grounded conductor is identified with a continuous white or natural gray outer covering and is properly connected in accordance with Order 1340—a, the fuse in the grounded identified conductor of branch circuits may be omitted.

(3) Fuses or circuit-breakers shall be placed at every point where a change is made in the size of the wire, unless the fuse or circuit-breaker in the larger wire will protect the smaller.

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 (h) 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) Plans in duplicate showing location and size of mains and distribution cabinets of the proposed installation shall be submitted to the Industrial Commission for approval before the installation is made.

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

(3) 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.

(4) Each motor shall be protected by an automatic overload protective device (fuses, thermal cut-outs, overload relays or circuit-breaker), except as provided in the exception to Order 1358—c-3. If fuses are used, one fuse shall be provided in each ungrounded conductor. If circuit-breakers or overload relays are used the number of trip coils shall not be less than required by (f) below. (See also Order 1352—b-6.)

Exception: If an A. C. starter when in running position opens all the ungrounded wires of the circuit automatically under overload and is equipped with the number of trip coils called for in (f) below, it may also serve as a circuit-breaker.

(5) Each motor shall be protected by running fuses, thermal cut-outs, relays or circuit-breaker in accordance with the following:

I. If fuses or thermal cut-outs are used, their rated capacity shall not exceed 125 per cent of the name plate current rating of the motor, except that when no fuses or thermal cut-outs of the required capacity exist, those of the next higher standard rating may be used.

II. If a circuit-breaker is used, it shall have a continuous current-carrying capacity of at least 110 per cent of the name plate current rating of the motor.

III. If an overload relay is used, its rated capacity shall not be exceeded when the motor it protects is carrying 110 per cent of its continuous current capacity as indicated on its name plate.

IV. If the circuit breaker or overload relay is of the time limit type, it shall have a setting of not over 125 per cent, and if of the continuous type, a setting of not over 160 per cent, of the name plate current rating of the motor.

Exception: (1) Motors of other than continuous rating or used on other than continuous load duty, shall be considered as being sufficiently protected by the fuses or circuit-breakers used to protect the conductors of the motor circuits. (See also Order 1341—c.)

(2) Continuous rated motors of two horse power or less shall be considered sufficiently protected by the fuses or circuit-breakers protecting the conductors of the motor circuits. (See also Order 1341—c.)

Note: To comply with the above order in the case of a squirrel cage or similar type motor having a large starting current, it will be necessary to use a motor starter or switch so designed that the protective device will be shunted or cut out of service during the starting

period, unless a time limit circuit-breaker or similar device is used, which will prevent the opening of the circuit during the starting period.

(b) *Type of Fuses Required.* Except in stations and substations (see Part 1), only fuses of the enclosed type (plug or cartridge) may be used. (See also Order 1141—a and exception, Section 114, Part 1.)

(c) *Tampering with Fuses.* Nothing shall be done to fuses, either temporarily or permanently, which will defeat the purpose for which they are installed, or which will increase the capacity above the rating of the fuse.

Note: The installation in fuses of conducting materials other than proper fusible elements, or the installation of more than one fusible element in one fuse case is forbidden by this order.

Such reprehensible practices as the placing of pennies behind plug fuses, the installation of link fuses or wires on the outside of cartridge fuses are also forbidden by this order.

(d) *Guarding Live Parts of Fuses.* (See also Orders 1310, 1350—a-4 and h, 1354.)

(1) All cartridge fuses and plug fuses larger than 15 amperes capacity shall always be so arranged that they may be disconnected from the supply circuit by properly placed switches. An individual switch shall be installed in each branch circuit of this or larger capacity.

Exception. Service entrance fuses may be placed on the supply side of the service switch in accordance with Exception 2 of Order 1324.

(2) Plug fuses of 15 amperes capacity or less shall be arranged so that they may be disconnected from the supply circuit in groups, if they are not arranged to be disconnected by individual switches.

(3) All fuses shall be installed in locked cabinets or otherwise made inaccessible to other than qualified persons while the fuses are alive.

Exception: Receptacles of plug fuses on so-called dead front or protected type panel boards need not be dead when fuse is removed.

Note: One method of obtaining the desired protection is by a construction in which the fuse and its exposed current-carrying parts are accessible only after they have been disconnected from the circuits.

(e) *Arcing or Suddenly Moving Parts.* Fuses and circuit-breakers shall be so located and shielded that persons will not be burned or injured by their operation.

Note: Handles or levers of circuit-breakers and similar parts may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them and hence should be guarded or isolated.

(f) *Interlocking Circuit-Breakers.*

(1) Automatic overload circuit-breakers shall have the overload trip coils arranged so that the operation of any one pole will open all of the ungrounded conductors simultaneously.

(2) In two- or three-phase three-wire circuits and two-phase four-wire circuits there shall be an overload trip-coil in each of two phases and in four-wire three-phase circuits there shall be a trip-coil in each phase.

(3) If a circuit breaker is used in place of a switch as permitted by Order 1350—a, Exception 2, it shall be so arranged that no one pole can be opened manually without disconnecting all the ungrounded conductors.

(g) *Fuses and Circuit-Breakers in Neutral Wires, Ground Wires and Fixture Canopies.*

(1) Permanently grounded conductors, including service wires (see also Order 1324), shall be arranged without fuses and circuit-breakers interrupting their continuity, unless the device used opens all conductors of the circuit with one operation. (See also Order 1350—d and exceptions.)

Exception: Two-wire and three-wire branch circuits, in which the conditions of the exception to (a-2) above are not met, shall have fuses in all branches.

(2) Automatic cut-outs shall not be placed in fixture canopies.

(h) *Accessibility Fuses and Circuit-Breakers.* All fuses and circuit-breakers shall be readily and safely accessible.

Order 1352. Capacity of Fuses and Circuit-Breakers.

(a) *Determining Size of Fuses and Circuit-Breakers.* The rated capacity of fuses shall not exceed the allowable carrying capacity of the wires they protect as given in Tables 3 and 3-A of Order 1341—a. Circuit-breakers shall not be set more than 30 per cent above allowable carrying capacity of the wires protected. (For exception to this order see a-5 above and Order 1341—c.)

(b) *Fuses for Branch Circuits.*

(1) Branch circuits in general, except as given in (3), (5) and (6) below, shall be protected by fuses of no greater rated capacity than—

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

Exception: Fixture wire or flexible cord of No. 18 or No. 16 A. W. G. shall be considered as properly protected by 15 ampere fuses.

(2) On a two-wire branch circuit and on either side of a three-wire branch circuit the number of outlets (see Definition 3, Order 1020) shall not exceed twelve.

Note: It is recommended that installations be designed so that lighting branch circuits are not loaded in excess of 1200 watts initially, in order to provide reserve capacity for future additions.

(3) Branch circuits supplying only sockets or receptacles of the mogul type or vapor lamps (see Order 1362) shall have the wires protected by fuses having a rated capacity not greater than

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

Exception: The wiring of such lamps, or fixtures for such lamps, shall be considered as protected by the above fuse sizes, if the size of such wires is No. 12 A. W. G. or larger. Taps from circuit wires to lamps or fixtures when No. 12 A. W. G. or larger and not longer than 18 inches shall also be considered as protected by the above fuse sizes.

(4) The number of mogul sockets or vapor lamps on a two-wire branch circuit and on either side of a three-wire branch circuit shall not exceed eight.

(5) Each heating appliance shall be supplied by a separate branch circuit protected in accordance with (a) above.

Exceptions: (1) Heating appliances of 6 amperes or 660 watts or less may be grouped with lamps, etc., under the protection of a single set of fuses, on branch circuits operating at 125 volts or less, provided the rated capacity of the fuses does not exceed 15 amperes.

(2) Heating appliances each of 10 amperes or 1200 watts or less may be grouped on a special heater circuit protected by fuses having a rated capacity not greater than 15 amperes.

(3) Subdivided circuits of a heater need not be separately fused.

(6) Each motor shall be supplied by a separate branch circuit protected in accordance with (a) above.

Exceptions: (1) Motors of one-fourth horse power or less may be grouped with lamps, etc., under the protection of a single set of fuses, on branch circuits operating at 125 volts or less, provided the rated capacity of the fuses does not exceed 15 amperes.

(2) Motors may be grouped under the protection of a single set of branch circuit fuses, provided the rated capacity of the fuses does not exceed 15 amperes and the total wattage of the circuit does not exceed 1200.

(3) The number and size of motors grouped under the protection of a single set of fuses, need be limited only by the maximum size of the fuses with which the thermal cut-outs can be safely used and each thermal cut-out shall be marked to indicate the size of this fuse.

Order 1353. Cut-out Boxes and Cabinets. (For switches, fuses, circuit-breakers, feeder and branch circuit panelboards, etc. (See also Orders 1312 and 1330—i.)

(a) *Material:* Cut-out boxes, switch cases, cabinets or other similar inclosures shall be of metal and of such design and construction as to secure ample strength and rigidity. (For exception see Order 1345—h-2, paragraph VI.)

(b) *Wiring Spaces, Gutters, Compartments.* (1) Cut-out boxes and cabinets which contain devices or apparatus connected within the box or cabinet to the wires of more than four power or eight lighting circuits, including branch circuits, meter loops, sub-feeder circuits, power circuits from lighting panels 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 box or cabinet directly opposite their terminal connections.

(2) The wiring spaces required by (1) above shall be rendered tight inclosures by means of covers, barriers or partitions which are firmly secured in position and which fit closely with the bases of devices and with the frame or door. The enclosed wires shall not be exposed when the doors of such cabinets or cut-out boxes are open.

(c) *Spacings Within Cut-out Boxes and Cabinets.* The spacing within cut-out boxes and cabinets 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 boxes and cabinets and current-carrying parts of devices and apparatus mounted within them as follows:

(1) There shall be an air space of at least 1/16 inch, except at points of support, between the base of the device and the wall of any metal box or cabinet on which the device is mounted.

(2) There shall be an air space of at least one inch between any live metal part (including live metal parts of enclosed fuses) and the door, unless the door is lined with an adequate insulating material or is of a thickness of at least that of No. 12 U. S. gauge metal, when the air space shall be not less than one-half inch.

(3) Except as noted above, there shall be an air space of at least one-half inch between the walls, back, gutter partition, if of metal, or door of any box or cabinet and the nearest exposed current-carrying part of the devices mounted within the box or 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.

(d) *Depth of Cut-out Boxes and Cabinets.* Cut-out boxes and cabinets shall be deep enough to permit the closing of the doors, when switches are opened as far as their construction will permit.

Order 1354. Switchboards and Panelboards. (See also Orders 1350—m, 1383 and 1384.)

(a) *Switchboards.*

1. Switchboards if accessible only to qualified persons shall be installed as required by Orders 1120—e and 1142 of Part 1.

2. If installed where accessible to other than qualified persons, as in workrooms of mills and factories, mercantile establishments, hotels and other public buildings, they shall in addition be guarded as required by Order 1310, and insulating floors, mats or platforms provided as required by Order 1120—c-2, Section 112 of Part 1. (See also Order 1350—h.)

(b) *Panelboards.*

(1) 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.

(2) The following minimum distances between bare live metal parts (bus-bars, etc.) shall be maintained:

I. Between parts of opposite polarity except at switches.

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

II. Between parts of the same polarity a distance sufficient to permit of convenience in handling shall be maintained.

(3) When there are exposed live metal parts on the back of board, a space of at least one-half inch shall be provided between such live metal parts and the cabinet in which the panelboard or cut-out is mounted.

Order 1355. Controllers.

(a) *Accessible and Indicating.*

The requirements for accessibility and the indication of the function of controllers, starting rheostats and auto-starters shall conform to Orders 1350—b and c for switches.

(b) *Contacts.* Controllers and rheostats shall be so constructed as to make and maintain good contact.

(c) *Resistors.*

(1) Resistors shall be placed on switchboards, or at a distance of at least one foot from combustible materials, or separated therefrom by slabs or panels of non-combustible, non-absorptive, insulating material such as slate, soapstone, or marble, somewhat larger than the resistors and secured in position independently of the supports of such resistors.

(2) Bolts for supporting the resistors shall be countersunk at least ⅛ inch below the surface at the back of the slab and the bolt heads shall be covered with insulating material or there shall be an air space of at least one inch between the back of the slab and the surface protected.

(3) For proper mechanical strength the slab used should be made of a thickness consistent with the size and weight of the resistor.

(d) *Guarding Live Parts of Controllers.*

All manual controllers, such as starting rheostats, auto transformer starters and other similar devices for starting motors shall have suitable casings or enclosures of such design as to permit of operation without opening the enclosure or shall be so located that the operator is at all times protected against danger.

Exception: Pre-setting speed devices and other devices manipulated by and accessible to qualified persons only are exempted from this order, provided they are within a locked enclosure.

Note: Manual speed regulators that may be used as motor starters are included in this order.

Order 1356. Transformers. (For Exception see Order 1301.)

(a) *Location.*

(1) Transformers shall not be attached to the wall of any building when the voltage exceeds 750.

(2) Oil transformers of more than 5 K. W. capacity shall not be placed on or inside of any building, except electrical test rooms, generating stations and substations, unless inclosed in a transformer vault. (See definition 52, Section 102, Introductory Part.)

(3) Air cooled transformers shall not be placed inside of any building, excepting generating stations or substations, if the highest voltage of either primary or secondary exceeds 750 volts, unless inclosed in a transformer vault.

(4) Air cooled transformers of less than 750 volts, with the exception of bell ringing and other signaling transformers, shall be so mounted that the case is a distance of at least one foot from combustible material or separated therefrom by non-combustible, non-absorptive insulating material, such as slate, marble or soapstone. This will require the use of a slab or panel somewhat larger than the transformer.

Exception: The requirements of (1), (2), (3), and (4) above do not apply to apparatus or fittings, the operation of which depends either wholly or in part upon special transformers embodied in the devices, or auto-transformers used in connection with motor starters, but all such apparatus or fittings shall comply to these orders in all other respects.

(b) *Auto-Transformers.* Transformers in which a part of the turns are common to both primary and secondary circuits shall not be used inside buildings to supply lighting circuits if the highest voltage involved exceeds 300 volts.

Order 1357. Motors and Generators. (See also Orders 1310 and Orders 1341—b and c.)

(a) *Bushings and Bases.*

(1) Bushings for lead wires coming through the frames of motors and generators shall be of non-absorptive insulating material.

Exception: Soft rubber may be used if not exposed to oils, grease or other deleterious substances in such quantities as to cause its rapid destruction.

(2) When terminal bases are used, they shall be of approved non-combustible, non-absorptive, insulating material such as slate, marble or porcelain.

(b) *Dripping.*

(1) Where there is likely to be oil dripping from motors and generators suitable drip pans shall be provided.

(2) Suitable guards or inclosures shall be provided to protect exposed current-carrying parts and the insulation of leads of motors and generators from dripping oil, excessive moisture, steam, vapors, chemicals or similar injurious substances.

(c) *Speed-Limiting Devices.* Machines of the following type shall be provided with speed-limiting devices unless the load and the mechanical connection thereto are of such a character 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 the 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 circuit-breaking device which will cut off the supply of energy when excessive speed is attained.

(d) *Weak Field.* Where the speed adjustment of direct current motors is accomplished by varying field resistance, and the nature of the load and the range of the field-rheostat are such as to make a dangerous speed attainable and no speed-limit devices are used, the field rheostats shall be arranged with low-voltage releases or other necessary devices so that the motor cannot be started or continued in operation under dangerously weakened field except where the operation of such a low-voltage release might result in serious injury to service or apparatus.

Exception: Motors which are designed to permit operating under weakened field are not included in the above.

(e) *Wiring.* Where speed-limiting devices or remote-control switches are electrically operated, the control circuits by which such devices are actuated shall be adequately guarded by conduit or otherwise, against mechanical injury.

(f) *Under or Low-Voltage Protection.* Where the restarting of the motor on restoration of voltage may result in injury to persons or apparatus, under or low-voltage protection, which

will cause and maintain the interruption of power to the main circuit upon reduction or failure of voltage, shall be supplied. (See also Order 1350—f-2.)

Exception: When the motor and driven machinery are isolated and accessible to qualified persons only, the provision of a disconnecting switch eliminates the hazard to persons.

(g) *Reverse-Phase Relays for Motors.*

(1) Electric freight or passenger elevators, operated by polyphase alternating current motors, shall be provided with protective devices (relays) which will prevent starting the motor if phase rotation is in the wrong direction or if there is a failure in any phase.

Exception: Limit switches placed in the elevator shaftway in accordance with Order 471 of the elevator code will make unnecessary the installation of reverse phase relays.

(2) Electric cranes operated by polyphase alternating current motors, shall have the runway feeders or other sources of supply protected by relays, which will prevent starting any of the motors on the crane if the phase rotation of these feeders is in the wrong direction.

(h) *Operation.* Only motors especially designed for the purpose may be run in series—multiple or multiple-series.

(i) *High Potential Systems.* (See also Order 1325.)

(1) Motors or generators shall not operate at voltages in excess of 2500, except in rooms accessible only to qualified electrical operators. (See Order 1301, Section 130.)

(2) Motors operating at voltages above 750 volts shall be wired with approved multiple conductor, metal sheathed cable in rigid metal conduits, or other suitable ducts.

Exception: Where not exposed to moisture, the sheathing may be omitted.

(3) When sheathing is required the ends of the sheaths shall be belled-out and bonded around splices by No. 6 A. W. G. wire and ground clamps.

(4) The insulation of the several conductors where leaving the metal sheath of cables, shall be protected from moisture, and mechanical injury by pot-heads or equivalent methods.

Note: Do not terminate the conduit at or close to the apparatus and bridge the gap with open wires. In the case of a belted motor which must be adjustable to some extent, a short portion of the conduit may be flexible.

Order 1358. Cranes.

(a) *Special Requirements.* In addition to complying with the other orders of this code that apply, all wiring and electrical equipment of cranes shall comply with the following requirements: (See also Section 131.)

(b) *Wiring.*

(1) All conductors except bare collector conductors, those between resistances and contact plates of rheostats and those subjected to severe external heat, shall be stranded rubber-covered and not smaller in size than No. 12 A. W. G.

(2) Insulation on wires between resistances and contact plates of rheostats shall conform to Order 1340—f.

(3) Wires subjected to severe external heat shall have slow-burning insulation.

(4) All wires, excepting bare wires, shall be run in conduit, armored cable, or shall be supported by knobs or cleats which separate them at least one inch from the surface wired over.

Exception: In dry places where space is limited and the distance between wires, as required by Order 1343—d-1 and h-1, cannot be obtained, each wire may be separately encased in flexible tubing securely fastened in place.

(5) Trolley conductors carried along crane runways, shall be rigidly and securely attached to their insulating supports at least every 20 feet and held at ends by strain insulators. If wires are run in a horizontal plane, they shall be separated at least 6 inches; if not run in a horizontal plane they shall be separated at least 8 inches; if spans are longer than 20 feet, the distance between wires shall be increased proportionately, but in no case shall spans exceed 40 feet. (See also Order 1340—b.)

Exception: Clamp ear hangers will be considered the equivalent of rigid supports.

(6) Crane runway conductors shall be located in such a position or so guarded that persons working on the crane or persons entering or leaving crane cab, are reasonably protected against making accidental contact.

(7) Bridge collector wires shall be held at ends by strain insulators and when spans of cranes exceed 50 feet, insulated supports, on which the wires may loosely lie, shall be provided every 30 feet.

(8) Bridge collector wires shall be kept at least 2½ inches apart and separated at all times at least 1½ inches from the surface wired over.

(9) Bridge collector wires shall not be smaller in size than specified in the following table for the various spans: (See also Order 1341—e.)

Length of Span—Feet	Size Wire Required—A. W. G.
0 to 30	6
31 to 60	4
Over 60	2

(10) 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.

(11) 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.

(c) *Switches, Fuses and Circuit-Breakers.*

(1) Runway trolley wires for traveling cranes or the feeder wires for other types of cranes shall be protected by fuses or circuit-breakers and controlled by a switch which can be locked in the open position. Fuses or circuit-breakers and switches shall comply with Orders 1350—h and 1351—d and shall be so located as to be easily accessible from the floor.

(2) All electric cranes shall be equipped with a main line switch connected into the leads from the crane runway wires, and so located in the cab as to be readily accessible to the operator. This switch shall comply with Order 1350—h and shall have means for locking in the open position.

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.

(3) With cranes or cab controlled monorail hoists having more than one motor, each motor shall be protected by fuses, a circuit-breaker or overload relays controlling line contactors.

If fuses are used, one fuse shall be provided in each conductor. If circuit-breakers or overload relays are used, the number of trip coils shall not be less than required by Order 1351—f-2.

Exception: Jib cranes, pillar cranes, and floor controlled hoists having a combined motor horse power of 10 or less need not have individual motor protection.

(4) Each hoisting motor shall be equipped with a limit switch so placed and so arranged as to disconnect the motor, apply the brake and stop the motor before the hook passes the highest point of safe travel.

(d) *Buffers at Travel Limits and Between Cranes.*

(1) The bridge and trolley shall be provided with substantial and effective buffers, preferably of the air-cushion, spring or similar type, or the curved rail with a radius larger than the wheel shall be employed.

(2) Where two or more cranes are operating on the same runway, substantial and effective buffers of the air-cushion, spring or similar type, shall be provided.

(e) *Brakes.*

(1) Each hoist motor shall be provided with a magnetic brake so arranged that the brake will be applied when the power is cut off from the brake magnet. This brake shall have sufficient torque to sustain at least one and one-half times the full rated load.

Note: On cranes where a combination mechanical load lowering brake and a magnet brake on motor shaft are employed, the two brakes together shall meet this requirement, but need not do so individually.

(2) Cranes which have a cab on the trolley shall be provided with a brake for the trolley motion.

(3) The bridge travel shall be provided with a brake.

(4) The brakes specified in (2) and (3) above shall be capable of producing a torque sufficient to retard at the rate of not less than one foot per second per second. When manually operated this rate of retardation shall not require a force on the brake lever in excess of 100 pounds.

Note: A maximum limit for retardation cannot be set as a general rule, but in no case should it be such as to introduce hazardous conditions when consideration is given to the character of the service and the characteristics of the equipment.

(f) *Grounding.* The metallic parts of portable cranes, derricks, hoists, and similar equipment on which wires, cables, chains

or other conducting objects are maintained shall be provided with an effective protective ground if operated in the vicinity of electric wiring or equipment over 100 volts to ground, whether the cranes or similar equipment are themselves electrically operated or not.

Note: Order 1313 requires the grounding of the motor-frames, the entire frame of the crane and the tracks.

(g) *Controllers.*

(1) Controllers shall be installed as required by Order 1355.

Exception: If the crane is located outdoors the insulation on wires between resistors and contact plates of rheostats shall be rubber where the wires are exposed to moisture and insulation is necessary and also where wires are grounded.

(2) If the crane operates over readily combustible material, the resistors shall be placed in an inclosure made of non-combustible material, thoroughly ventilated and so constructed that it will not permit any flame or molten metal to escape in the event of burning out of the resistors. If the resistors are located in the cage, this result may be obtained by constructing the cage of non-combustible material and providing sides which inclose the cage from its floor to a height of at least 6 inches above the top of the resistors.

(3) If each controller is not arranged to return automatically to the "off" position, when the operating handle is released, each crane shall be provided with a device which will disconnect all motors from the line on failure of power and will not permit any motor to be restarted until the controller handle is brought to the central position or until a reset switch or button is operated.

(4) Manual controllers or the manually operated part of remote controllers shall be provided with a device that will definitely indicate to the operator's sense of feeling when the controller is in the "off" position.

(5) All controller handles shall, as far as practicable, be so arranged that the movement is in the same general direction as the resultant movement of the object controlled, and so that the operator can readily face the direction of travel.

SECTION 136. LIGHTING FIXTURES AND APPLIANCES, INCLUDING SIGNS AND OUTLINE LIGHTING

Order 1360. Fixtures.

(a) *Construction of Fixtures.*

1. Fixtures shall be composed of metal or wood, or other materials approved for the purpose. Materials other than metal shall be reinforced by metal or the fixtures shall be otherwise constructed to secure the requisite mechanical strength.

2. In all fixtures not made entirely of metal, wireways shall be lined with metal unless approved armored conductors with suitable fittings are used.

Exception: This requirement shall not apply to wireways in glass, marble or similar non-absorptive insulating materials.

3. 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. Tubing used in making threaded arms and stems shall be composed of metal having a thickness not less than .04 inch. It shall not be kinked, flattened or cracked.

4. Fixtures shall be constructed so that wires may be drawn in, remain in place, or withdrawn without injury to the insulation of the wires.

Note: To accomplish this result all burrs and fins in wireways should be removed and all edges which wires pass should be smooth and rounded so as to prevent the possibility of cutting or abraiding the insulation at time wires are inserted or later through movement or vibration of the fixture. It is suggested that openings for the entrance of wires be made large.

5. Fixtures exposed to moisture, whether located indoors or outdoors, shall be so constructed that water cannot enter the wireways, sockets or other electrical parts.

6. Fixture studs which are not parts of outlet boxes, hickeys, tripods and crowfeet shall be made of malleable iron or other approved material.

7. 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.

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

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

10. 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. The insulating strip or sheet shall be secured by rivets or screws which shall be so placed or countersunk that the desired effective insulation distance will be obtained.

Note: A strip of a good grade of hard fiber, 1/16 inch in thickness, permanently attached to the canopy at the ends and at intermediate points in such a manner that the strip will extend permanently at least 3/16 inch beyond the upper edge of the canopy rim, will be accepted. Where this is impracticable, a flat sheet of said 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.

11. 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.

(b) *Wiring of Fixtures.* (See also Order 1346.)

1. No conductor shall be smaller than No. 18 A. W. G. 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 stem.

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

2. Each fixture shall be so wired that all screw shells or sockets will be connected to the same fixture stem wire, or supply wire, or terminal in the fixture, and this wire or terminal shall be marked in an approved manner by which it may be readily distinguished. The marked wire shall in all cases be the grounded wire. (See also Orders 1314 and 1340—a.)

3. Chain fixtures shall be wired with flexible conductors so arranged that the weight of the fixture will not put tension on the conductors.

4. Fixture wire, flexible cord or rubber-covered wire shall be employed, unless the wiring is exposed to temperatures in excess of 120 degrees F. (49 degrees C.), in which case conductors having slow-burning or other heat-resisting covering shall be used. Fixtures intended for outdoor use shall be wired with rubber covered conductors. Wires shall always be so disposed as to avoid exposure to high temperatures as far as practicable. Fixtures intended for use in rooms where inflammable gases may exist shall consist of rigid stems, internally wired with rubber covered conductors, soldered directly to the circuit, and shall be equipped with vapor tight globes. (See also Order 1312.)

5. 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. (See also Order 1346—b.)

(c) *Installation of Fixtures.* (See also Order 1343—m.)

1. Fixtures having exposed noncurrent-carrying metal parts, if not permanently and effectively grounded (see also Order 1313), shall be insulated from their supports by insulating joints placed as close as possible to the ceiling or wall and by canopy insulators if wall or ceiling is composed of sheet metal or plaster on metal lath.

Exception: Such insulating joints and canopy insulators may be omitted with straight electric fixtures connected to knob-and-tube work or open work on walls and ceilings of wood frame and plaster on wood lath construction.

2. Fixtures having so-called flat canopies, tops or backs, shall not be installed where outlet plates are used.

Note: It is recommended that for all side wall and partition outlets in concealed work in new buildings under construction outlet boxes having a depth of approximately 1½ inches be used. Such boxes should have covers which will reduce the opening to not more than three inches in finished plaster wall. Switch boxes are also suggested for this purpose.

3. No externally wired fixture shall be located in the immediate vicinity of especially inflammable 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.

4. 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.

Note: This order does not forbid the disconnection of a socket or sockets when necessary in order to make possible the lowering of the fixture for inspection.

5. Fixtures shall be supported in a substantial manner. (See also Order 1343—m.)

Note: Ordinary fixtures may be supported from gas pipe, conduit, outlet boxes or fixture studs. Fixtures known as ceiling collars, especially constructed for the purpose of supporting a shade, bowl or globe at ceiling, may be fastened to the plaster or wall by means of wood screws, providing such support is substantial within the meaning of the order. Wall brackets with specially designed backs of metal, composition, wood or other approved material, made to fit flat against the wall (where outlet boxes are used), may be fastened to the plaster or side walls by means of wood screws, if such method provides a substantial support. Proper grounding should be provided where required by Order 1313—c.

(d) *Lamp Sockets and Receptacles.* (See also Order 1346—f and k.)

1. Lamp holding devices shall be classed according to diameters of lamp bases, as candelabra, medium and mogul bases, to be known respectively as ½-inch, 1-inch and 1½-inches nominal sizes.

Note: (1) It is recommended that 660 watt sockets and receptacles be used wherever the attachment of flexible cords thereto is likely.

(2) Receptacles for attachment plugs (convenience outlets) are strongly recommended in order to facilitate the use of electrical appliances which, otherwise, must be connected to sockets designed primarily only as lamp holders. (See (10) below.)

2. The inside of metal shells shall be lined with insulating material, which shall prevent the shell from becoming a part of the circuit, even though the wires inside the sockets should become loosened or detached from the position under the terminal screws.

3. 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.

4. The cap also shall be lined.

5. 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 with 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.

6. Lead wires furnished as a part of sockets and intended to be exposed after installation shall be of approved stranded, rubber-covered wire, not less than No. 14 A. W. G. (No. 18 A. W. G. for candelabra socket) and shall be sealed in place.

7. In places where combustible dust is thrown into suspension in the air in sufficient quantities to produce explosive mixtures, dust-tight fixtures enclosing lamps and sockets shall be used. Such fixtures shall be supported by conduit hangers or chains to prevent any strain on the wires. Where rubber-covered wire is used it shall have insulation not less than 3/64-inch thick. (See also Order 1312.)

8. Sockets and receptacles installed over especially inflammable material or where exposed to flyings of combustible 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. (See also Order 1312.)

9. 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 A. W. G. which are soldered directly to the circuit wires but supported independently thereof.

Note: Basements of residences ordinarily would not come under the classification of damp or wet places, but if sockets or fixtures can be reached from the floor or while a person is in contact with other grounded surfaces, they must of course be constructed of non-combustible, non-absorbent insulating material or exposed metal parts must be grounded in accordance with Order 1313—c.

10. Receptacles for attachment plugs, when located less than four feet above the floor, shall be of the flush type having live parts suitably guarded against contact.

Note: Edison screw receptacles are not considered as having their live parts suitably guarded. Flush receptacles in accordance with this order are recommended for use at all elevations.

(e) *Rosettes.*

Separable rosettes which make possible a change in polarity shall not be used. (See Order 1340—a.)

(f) *Inflammable Matter Attached to Fixtures.*

Decorations of paper, cotton, cloth or other combustible materials shall not be attached to wires, globes, shades, lamp bulbs or other parts of fixtures liable to temperatures which may char or ignite such materials.

Note: Properly constructed cloth, parchment or similar shades of portable table and floor lamps are not included in this order.

(g) *Pendant Cords.*

Pendant lamp cords shall hang vertically in space and neither the cord nor the lamp shall be in contact with any other body. (See also Order 1346—c.)

Order 1361. Gas-Filled Incandescent Lamps.

(a) *Size of Base.*

Gas-filled incandescent lamps shall not be equipped with medium bases above 250 watts rating, nor with mogul bases if above 1500 watts rating.

(b) *When Installed in Show Windows.*

Gas-filled incandescent lamps shall not be located in show windows nor where liable to contact with inflammable material unless installed in approved fixtures equipped with shades or guards or suitably designed to operate at a safe temperature.

Order 1362. Mercury Vapor Lamps. (See also Order 1352-b-3.)

(a) *Enclosure of Resistances and Regulators.*

Enclosed mercury vapor lamps shall be equipped with only such resistances or regulators as are enclosed in non-combustible cases, such resistances or regulators being treated as sources of heat. Where these resistances or regulators are subject to flyings of lint or combustible material, all openings in their casings shall be covered by fine wire gauze.

(b) *Mercury Vapor Lamps Enclosed in Fixtures.*

Fixtures carrying enclosed mercury vapor lamps shall be wired with insulated conductors not smaller than No. 12 A. W. G.

Order 1363. Arc Lamps and Constant-Current Series Lamps. (See also Order 1323.)

(a) *Disconnecting Device.* A suitable device shall be provided by which each arc lamp or other device on series circuits may be safely and entirely disconnected from the circuit before it is handled, unless the lamps are accessible only to properly qualified persons, worked on only from suitably insulated stools, platforms or tower wagons and treated always as under the full voltage of the circuit concerned.

(b) *Wires.*

(1) Lamps when arranged to be raised and lowered, either for carboning or other purposes, shall be connected with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 A. W. G.

(2) These branch conductors shall have a carrying capacity at least 50 per cent in excess of the normal current required by the lamp.

(3) Interior wiring for arc lamps shall have an approved rubber insulating covering. Wires shall always be in plain sight, and never incased.

(4) Wires for arc and constant-current series lamps shall be supported on glass or porcelain insulators, which separate the wire at least one inch from the surface wired over and shall be kept rigidly at least eight inches from each other, except on hanger-boards or in cut-out boxes or like places, where a less distance is necessary.

(5) Incandescent lamps in series circuits shall have the wires installed as required above and each lamp shall be provided with an automatic cut-out.

(c) *Resistors and Regulators.*

(1) Resistors or regulators of arc lamps on constant-potential circuits shall be inclosed by non-combustible material, and shall be treated as sources of heat. Incandescent lamps shall not be used as resistors.

(2) Economy and compensator coils for arc lamps shall be mounted on non-combustible, non-absorptive, insulating supports, such as glass or porcelain, allowing an air space of at least one inch between frame and support, and shall in general be treated as sources of heat.

(d) *Guarding.*

(1) Arc lamps shall be supplied with globes and wire nettting around the globes (having a mesh not to exceed 1¼ inches) and shall be protected by spark arresters. Broken or cracked globes shall not be used.

(2) Lamps shall be placed out of reach or otherwise suitably protected.

Note: Outside lamps should be suspended at least 10 feet above footways and 15 feet above roadways; inside lamps, at least 8 feet above the floor.

(3) Lamps shall be secured from falling on persons or traffic passing below, and the hanger rope, chain or other means adopted for holding the lamps shall be regularly and systematically inspected.

(e) *Supports.* All metal cable or chain supports for constant-current series lamps shall be effectively insulated from the lamp and shall also be insulated at a point not less than 8 feet from the ground.

Order 1364. Decorative Lighting.

For temporary installations of approved systems of decorative lighting, the difference of potential between the wires of any circuit shall not be over 150 volts, and not more than 15 amperes shall be dependent on the one cut-out.

Order 1365. Outline Lighting. (Exterior.) (For size of fuses required see Order 1352.)

(a) *Wiring.*

(1) For outline lighting, open wiring, conduit or metal-trough construction may be used but raceways shall not be used.

(2) Wires for use in rigid or flexible steel conduit shall comply with requirements for conduit work. (See Order 1342.)

(3) Where armored cable is used, the cable shall be protected from moisture by lead sheath between armor and insulation.

(4) For open work, wires shall be rubber-covered, not less than No. 14 A. W. G. and shall be rigidly supported, on non-combustible, non-absorptive insulators not over 4½ feet apart, which separate the wires at least one inch from the surface wired over. If the wires are liable to be disturbed, the distance between supports shall be shortened.

(5) In those parts of circuits where wires are connected to receptacles which hold them at least one inch from the surface wired over, and which are placed not over one foot apart, such receptacles will be considered to afford the necessary support and spacing of the wires.

(6) Between receptacles more than one foot, but not more than two feet apart, an additional non-combustible non-absorptive insulator maintaining a separation and spacing equivalent to those of the receptacles shall be used.

(7) Except as above specified, wires shall be kept apart at least 2½ inches for voltages up to 300 and four inches for higher voltages.

(8) Metal-troughs shall be weatherproof, and other details shall comply with such requirements of Orders 1340–1346, inclusive, as apply, and Order 1375.

(b) *Sockets and Receptacles.*

(1) Sockets and receptacles shall be of the keyless weatherproof type and wire connections shall be soldered.

(2) Miniature base devices shall not be used.

(c) *Cabinets.*

(1) Cut-outs, switches, flashers, transformers, and similar appliances shall be of proper types and shall be installed as required for such appliances.

(2) Outside of building, such equipment shall be installed in weatherproof cabinets, or separate weatherproof compartments of the sign.

(d) *Switches.* Outline lighting shall be protected by switches which disconnect all conductors. (See also Order 1350.)

Order 1366. Signs. (For size of fuses required see Order 1352.)

(a) *Switches.* Electric signs, located as noted in (c) below shall be provided with switches, which disconnect all feed wires of the sign, and which shall be either located within sight of the sign or arranged so that they can be locked in the open position.

Note: It is recommended that where the capacity of the sign exceeds 15 amperes, a switch which will disconnect all wires be installed on the outside, within 7 feet from the ground.

(b) *Connectors.*

(1) Electric signs with changeable connections shall be so arranged that the changeable connections can be changed manually only by connectors in which all poles of the circuit are simultaneously interrupted.

(2) All current-carrying parts of pin-and-socket connectors shall be provided with guards, so as not to be exposed to contact.

(c) *Accessibility and Guarding.*

(1) Electric signs, any parts of which are at an elevation greater than 30 feet above the ground, or at an elevation above a roof greater than the distance from the edge of the roof, shall be provided with substantial safely accessible runways, ladders or platforms from which all replacements and other necessary adjustments can be made. Provision for supporting workmen by safety belts shall be made in the construction and maintenance of signs so located.

(2) Electric signs outside buildings shall have no current-carrying parts normally exposed to contact.

(3) The exposed noncurrent-carrying metal parts of a sign shall be grounded if within reach of any grounded surfaces, including metal work of the building structure.

Order 1367. Heating Devices. (See also Order 6037, General Orders on Fire Prevention and Order 1352.)

(a) *Flexible Cord.*

(1) Flexible cords for smoothing and pressing irons, and for all heating devices requiring over 250 watts shall be of the packing-house type in damp places, and of the electric-heater type (rubber and asbestos covered) in dry places.

(b) *Guarding.* Stationary heaters, such as radiators, ranges, plate-warmers, etc., shall be so located as to furnish ample protection between the device and surrounding combustible material.

Order 1368. Electric Furnaces and Welders. (See also Order 46, General Orders on Safety, and Order 1352.)

(a) *Inclosure Required.* Electric furnaces and apparatus used for arc welding, where intensely glowing, incandescent, or arcing parts are exposed shall be inclosed, so that those parts will not be readily accessible or visible to unauthorized persons, and warning signs shall be displayed.

(b) *Protective Hoods, Goggles, etc., Required.* Suitable protecting screens, hoods, goggles, gloves, and other devices shall be provided for the authorized operators who must work or come near such exposed parts.

(c) *Guarding.* Except at points where necessarily left exposed (as at spot welder contacts) all current-carrying parts of furnaces, welders, and control equipment shall be suitably guarded with inclosures or barrier guards.

SECTION 137. THEATERS, MOTION-PICTURE HOUSES, PICTURE MACHINES

(Order 1310--b-2 requires conduit, armored cables or metal raceways in theaters.)

Order 1370. Special Requirements.

In addition to complying with the other orders of this code, all wiring and electrical equipment of theaters shall comply with the following special orders (1371–1379 inclusive): (See Orders 5500 and 5501 of Building Code given in Appendix E.)

Order 1371. Service. (See also Section 132.)

(a) *Independent Supply and Branch Lines for Emergency Lighting.*

(1) Electrical emergency lights, including all supply and branch lines, shall be entirely independent of the other lights and electrical equipment of the theater.

Note: By "emergency lights" are meant exit lights and lighting in lobbies, stairways, corridors, and other portions of the theater, to which the public have access, which are normally kept lighted during the performance.

(2) Where it is practicable to obtain energy from two separate street mains, two separate and distinct services shall be installed. One of these services shall be of sufficient capacity to supply current for the entire electrical equipment of the theater, including possible additional portable load, while the other service shall be at least of sufficient capacity to supply current for all emergency lights.

(3) Where it is not practicable to obtain energy from two separate street mains, the feed for emergency lights shall be taken from a point on the street side of the main service fuses.

(4) Where the source of energy is an isolated plant within the same building, an auxiliary service of sufficient capacity to supply all emergency lights from some outside source or a suitable storage battery within the premises shall be installed.

Order 1372. Fusing and Control of Exit Lights.

Emergency lights shall not have more than one set of fuses between them and their service fuses, shall be fed independently of the stage lighting, shall be controlled only from the lobby or other convenient place in the front of the house, and fuses and control shall be accessible only to authorized persons.

Order 1373. Dressing Room Lamps.

All pendant lights shall be equipped with armored cable, or steel armored flexible cord, and shall be provided with guards which are sealed or locked in place.

Order 1374. Switchboards.

(a) *Construction and Guarding.*

(1) Stage switchboards shall be constructed as required by Order 1142, Section 114 of Part 1, and in addition shall be of the "dead-front" type so that the operator is at all times protected against any possibility of contact with live metal parts.

(2) Stage swichboards shall have a metal hood over the top running the full length of the board and fully protecting same from anything falling from above.

(b) *Dimmer Switches.* Switches controlling circuits of which dimmers form a part shall be arranged to disconnect the dimmer completely, except that on three-wire mains with grounded neutral the neutral shall be run through to the dimmer without a switch in it.

(c) *Dimmers to be Inclosed.* Dimmers shall be placed in a well ventilated non-combustible inclosure, accessible only to qualified persons.

Note: A fireproof chamber is recommended.

Order 1375. Stage Wiring.

(a) *Plug Receptacles.*

(1) Plug receptacles for arc and incandescent lamps shall be different, so that arc lamps cannot be connected onto an incandescent lamp receptacle and vice versa.

(2) Plug receptacles shall be controlled from switchboard only.

(3) Plug receptacles shall not be rated at less than 35 amperes for arc lamps, and 15 amperes for incandescent lamps.

(4) Plug receptacles shall be wired to full capacity, but in no case shall a wire smaller than No. 6 A. W. G. be used for arc lamps, nor smaller than No. 12 A. W. G. for incandescent lamps.

(b) *Footlights, Borders and Proscenium Sidelights.* (See also Order 1352.)

(1) The lamp receptacles shall be inclosed in approved outlet boxes or mounted in approved footlight sections constructed of sheet iron or steel, of a thickness not less than No. 20 U. S. Sheet Metal gauge, and treated to prevent oxidation.

(2) Cables for borders shall be of the stage cable type (see also Order 1346—d-3) and shall be suitably supported to prevent mechanical strain at connections and abrasion to cable. Conduit construction shall be used from switchboard to point where cables must be flexible to permit raising and lowering of border.

(3) For the wiring of footlights, borders and proscenium sidelights, wire with slow-burning insulation shall be used.

(4) Borders shall be suspended by wire rope and shall be insulated therefrom by at least one strain insulator inserted in each rope at the border.

(5) Borders and proscenium sidelights shall be provided with suitable guards to prevent scenery or other combustible material coming in contact with lamps.

(c) *Strip and Bunch Lights.*

(1) Strip and bunch lights shall have lamp receptacles inclosed in outlet boxes or mounted in inclosures of sheet iron or steel, of a thickness not less than No. 20 U. S. Sheet Metal gage, and treated to prevent oxidation.

(2) The cables supplying strip and bunch lights shall be tubed in a suitable manner where passing through the metal and shall be secured to prevent excessive strains from coming on the wire connection and the connections to the lamp receptacles shall be soldered.

(d) *Scene Docks.* Where lamps are installed in scene docks, they shall be so located or guarded that they will not be liable to mechanical injury.

(e) *String and Festoon Lights.*

(1) String and festoon lights shall be made up of proper fittings for such use. Joints and splices in wires shall be soldered and taped and staggered.

(2) Where lamps are used in lanterns or similar devices, effective guards shall be used.

(f) *Special Electrical Effects.*

(1) Bracket fixtures used for lights on scenery shall be securely fastened in position and have inclosed wiring. Fixture stems shall project three inches beyond the back of scenery and have terminal bushings.

(2) Where devices are used for producing special effects such as lightning, waterfalls, etc., the apparatus shall be so constructed and located that flames, sparks, etc., resulting from the operation cannot come in contact with combustible material.

Order 1376. Curtain Motors and Ventilating Flues.

(a) *Curtain Motors.* Curtain motors shall be of the inclosed type. (See also Order 1357.)

(b) *Ventilating Flues.*

(1) Where dampers for ventilating flues are released by an electric device, the operating circuit shall be normally closed.

(2) The magnet operating damper shall be wound to take the full voltage of the circuit from which it is supplied without the use of a resistance device and must not heat more than normal for apparatus of similar construction. It shall be located in a loft above the scenery and shall be installed in a suitable iron box with tight self-closing door.

(3) Such dampers shall be controlled by at least two standard single pole switches mounted within iron boxes provided with self-closing doors without lock or latch, and located, one at the electrician's station and the other as designated.

Order 1377. Portable Equipment.

(a) *Arc Lamps.*

(1) Arc lamps for stage effects shall each be in charge of a competent operator, except that one operator may have charge of two lamps when they are not more than ten feet apart, and are so located that he can properly watch and care for both lamps.

Note: Unless the two lamps are within arms reach of each other and on the same level, one operator cannot properly watch and care for both lamps.

(2) Arc lamps shall be constructed of substantial materials capable of withstanding hard usage, shall be properly ventilated but in a manner to prevent sparks from being emitted and shall be constructed so that neither carbons nor live parts will be brought into contact with the metal casing during operation.

(b) *Portable Plugging Boxes and Connectors.*

(1) Portable plugging boxes shall be constructed so that no current-carrying part will be exposed, and each receptacle shall be protected by fuses mounted on slats or marble bases and inclosed in a fire-proof cabinet equipped with self-closing doors. The bus-bars of portable plugging boxes shall have a carrying capacity equivalent to that required for the total number of receptacles, each receptacle to be rated at not less than thirty amperes. The master cable supplying portable plugging boxes shall be provided with approved terminal lugs.

(2) Pin plug connectors shall be so installed that the female part of the plug will be on live end of cable, and shall be so constructed that tension on the cable will not cause serious mechanical strain on the connections.

(c) *Flexible Cords.* Flexible cords used from receptacles to arc lamps, bunches and other portable equipments shall be stage cable (see also Order 1346—d-3) except that for the purpose of feeding a stand lamp, under conditions where cords are not liable to severe mechanical injury, a reinforced cord may be used, provided the protecting cut-out is fused for not over 10 amperes.

Order 1378. Picture Machine Equipment and Booths—Theater Type.

(a) *Compliance With Other Orders.* For construction of booths, ventilation, machines, flues, see Building Code, Part VI, Section 18.

(b) *Lamps.*

(1) Arc lamps shall be constructed entirely of metal of a thickness not less than No. 24 U. S. Sheet Metal gauge, except where use of insulating material is necessary, and shall be con-

structed in such a manner as to provide safeguards against fire or accident.

(2) Incandescent lamps shall be inclosed in such manner as to attain the same ends.

(c) *Wiring.* All exposed wiring in the booth shall have slow burning insulation.

(d) *Switches.* Each lamp of a machine shall have a separate switch located in the booth.

(e) *Equipment.*

(1) Generators, rectifiers and other equipment for transforming electric current shall not be placed within the booth.

Exception: If the booth is not less than 10 feet wide, by 19 feet long, by 8 feet high, and all such equipment is inclosed in fireproof material or thirty mesh wire screen, this requirement will be waived.

(2) Fuses, switches, flashers or other devices for control of lighting or motors shall not be located within the booth.

Exceptions: (1) Switches and dimmers for auditorium and stage lighting may be located within the booth and shall comply with Order 1374.

(2) Fuses and switches for picture machine equipment may be located within the booth.

(f) *Rheostats.* Rheostats, transforming devices or any substitutes therefor shall be of types expressly designed for the purpose.

Order 1379. Picture Machine Equipment—Miniature Portable Type. (See also Order 5539 of Building Code.)

(a) *General.* All equipment including all attachments, current-controlling devices, motors if any, and other parts employed shall be constructed so as to minimize the hazards of operation, and to safeguard against fire or accident.

(b) *Rating.* The entire equipment shall consume not more than 660 watts.

(c) *Lamps.* Lamps shall be constructed in such a manner as to provide safeguards against fire or accident.

(d) *Control Apparatus.* Rheostats, transformers, switches and other similar current-controlling devices shall be attached to and form a part of the machine and shall have no live parts exposed.

SECTION 138. PUBLIC GARAGES

(For definition of public garage see Order 1310—b-2.)

Order 1380. Special Requirements.

In addition to complying with the other orders of this code that apply, all wiring and electrical equipment of public garages shall comply with the following special orders (1381–1383, inclusive).

Order 1381. Wiring.

(Conduit, armored cable or metal raceways are required in all public garages by Order 1310—b-2.)

(a) *Wall Outlets.*

Conduit, armored cable (see Order 1332—b) or metal race ways (see Order 1333—a) shall be so installed that no outlet, junction box, wall receptacle, etc., will be located less than four feet from the floor.

(b) *Floor Outlets.* Floor outlets shall not be used.

Order 1382. Portables. (See also Order 1346—f.)

(a) *Flexible Cord.*

(1) Flexible cords for portable equipment shall comply with Order 1346—d-2.

(2) Flexible cords for pendant lamps shall comply with Order 1346—c-4.

(3) Cables for charging purposes shall comply with Order 1346—d-3.

(b) *Connectors.*

(1) The portable cord shall carry the male end of an approved pin-plug connector, or equivalent device, 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 four feet above the floor.

(2) Current-carrying parts of connectors shall be guarded to prevent accidental contact.

(3) Connectors for charging purposes shall have 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 cable. Live parts shall be guarded from accidental contact. The fixed, or wall connector shall be kept at least four feet above the floor.

(c) *Portable Hand Lamps.* Portable hand lamps shall comply with Order 1346—m.

Order 1383. Location of Equipment.

(a) *Switchboard and Charging Panels.* Switchboards and charging panels, at or upon which are mounted devices which in operation may cause sparking, shall be located in separate room or inclosure, provided for this purpose only, unless all such sparking or arcing parts are at least four feet above the floor or surrounded by explosion-proof inclosure.

(b) *Motors or Generators.* Motors or generators not actually a part of a vehicle, if not located at least four feet above the floor, shall be of the explosion-proof type.

Order 1384. Special Precautions.

(a) *Location of Cutouts, Switches, etc.* Cut-outs, switches and receptacles shall be placed at least four feet above the floor.

(b) *Hatch Limit Switches.* Hatch limit switches of elevators shall be located at least four feet above the lowest floor level.

SECTION 139. SIGNAL EQUIPMENT CONNECTED TO SIGNAL LINES AND RADIO SIGNALING APPARATUS

Order 1390. Scope of Orders.

Orders 1391 and 1392 govern wiring and other protective arrangements for telephone, telegraph (except radio signaling apparatus) district messenger and call-bell circuits, fire and burglar alarms, and all similar systems which are hazardous only because of their liability to become crossed with or subjected to induced voltages from electric light, heat or power circuits, or because of exposure to lightning.

Orders 1393–1399, inclusive, govern radio signaling apparatus and wiring.

Order 1391. Requirements for Wires and Cables Supported on and Entering Buildings, Protectors and Interior Wiring of Signal Equipment.

(a) *Signal Wires on the Outside Walls of Buildings.* Signal wires on the exterior of buildings shall not come nearer than four inches to supply wires, except when in conduit, unless separated therefrom by a continuous and firmly fixed non-

conductor to maintain permanent separation. This nonconductor shall be in addition to the insulation of the wires.

(b) *Insulating Joint in Aerial Cables.* Where metal sheathed aerial cables, which are liable to contact with electric light or power wires, enter a building the sheath shall be interrupted by means of an insulating joint or by equivalent means placed immediately outside the building.

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.

(c) *Insulation of Drop Wires.* The wires from the last outside support to the entrance to building (see (f) below) and wires attached to the outside walls of buildings shall have a rubber insulation not less than 1/32 of an inch in thickness and shall be covered by a substantial braid; on frame buildings or frame portions of other buildings wires shall be inclosed in conduit or supported on glass or porcelain insulators, or knobs. (See exception following 1391—f, see also exception following 1391—i.)

(d) *Entrance Bushings and Drip Loops.* Wires shall enter building either through non-combustible, non-absorptive insulating bushings or through rigid conduit. Bushings shall be installed in a manner to prevent entrance of moisture to the building. Conduit shall be so placed as to prevent the entrance of moisture, and fitted with an approved bushing or service head. (See exception following 1391—f, see also exception following 1391—i.)

Note: More than one wire may enter through the same bushing if desired.

(e) *Protector Required. Location.* Signal wires shall be provided with an effective protective device (see (i) below) located as near as practicable to the entrance of wires to building and in a readily accessible place. The protector shall not be placed in the immediate vicinity of inflammable materials, or where exposed to inflammable gases, dust or flyings. (See also Order 1392—a-2 and exception to 1391—i.)

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.

(f) *Wires from Entrance to Buildings to Protectors* shall be inclosed in conduit or supported on porcelain insulators of a

type and so spaced that the wires will not make contact with other objects or the surface wired over (see exception to 1391—i).

Exception: When wires are carried in cables, Orders 1391, (c), (d), and (f) do not apply. The cable may be of the metal sheath type with conductors insulated with paper or other suitable material, or it may be of non-metallic sheath type, in which case the insulation on the individual conductors shall conform to Order 1391—c, except that the braid on individual conductors may be omitted.

(g) *Protector Ground Wire.* (See exception under Order 1391—i.)

The ground wire of the protective device shall be run in accordance with the following requirements:

1. It shall be of copper and not smaller than No. 18 A. W. G.

2. Where exposed to mechanical injury it shall be guarded and on poles or where a ground wire on the outside of building walls is near a roadway, sidewalk or pathway, it shall be protected for a distance of 8 feet from the ground by a wooden moulding or by conduit, which if of magnetic material shall be electrically connected at both ends to the ground wire.

3. It shall have a rubber insulation of not less than 1/32 of an inch in thickness which shall be covered by a substantial braid.

4. It shall be run in as straight and short a line as practicable to a permanent and effective ground.

(h) *Protector Ground Connection.* (See exception under Order 1391—i.)

1. The permanent and effective ground called for in (g) above shall be obtained by connecting to extensive underground water or gas pipe systems, to a ground rod or pipe driven into permanently damp earth, or to a metallic plate or other body buried in permanently damp earth.

2. Connection shall always be made to water pipes where practicable.

3. If attachment is made to gas pipe, the connection in all cases shall be made between the meter and the street mains.

4. When the ground wire is attached to a water pipe or a gas pipe it shall be connected by means of an effective ground clamp fastened to a thoroughly cleaned portion of the pipe, or the pipe shall be thoroughly cleaned and tinned with rosin flux solder, and the ground wire wrapped tightly around the pipe and thoroughly soldered to it.

5. When the ground wire is attached to a ground rod driven into the earth, the ground wire shall be soldered to the rod in a similar manner as specified in (4) above.

6. In all cases the ground wire shall be so attached to the rod or pipe as to give a reliable connection both mechanically and electrically, and in such manner as to prevent corrosion when the joint is buried in the earth.

7. Where buried plate or other metal electrode is employed, the ground wire shall be securely fastened to it in such manner as to make a reliable electrical and mechanical contact.

8. Steam or hot-water pipes shall not be used for a protector ground.

(i) *Requirements for Signal Protectors.* The protector to be approved shall comply with the following requirements:

1. It shall be mounted on a non-combustible, non-absorptive insulating base, so designed that when protector is in place all parts which may be alive will be thoroughly insulated from the surface on which the protector is mounted.

2. It shall have an arrester between each line wire and ground and a fuse in each line wire.

3. The fuses shall be so placed as to protect the arresters.

4. The protector terminals shall be so marked as to indicate clearly the "line," "instrument" and "ground" terminals.

Exception: Orders 1391—c to i, inclusive, do not apply when the entire circuit is run underground from the central station to the block in which the building is located, provided the circuit within the block is so placed as to be free from liability of accidental contact with electric light and power wires of over 250 volts.

(j) *Wires Inside Buildings.*

1. Wires beyond the protector, or wires inside buildings where no protector is used, shall be insulated, neatly arranged and securely fastened in place, in a convenient and workmanlike manner.

2. They shall not come nearer than two inches to any electric light or power wire in the building, unless inclosed in conduit or separated therefrom by a continuous and firmly fixed nonconductor creating a permanent separation; this nonconductor shall be in addition to the insulation on the wire. (See also Order 1343—j-1.)

3. Where wires are bunched together in a vertical run within any building, they shall have a fire-resistive covering suffi-

cient to prevent the wires from carrying fire from floor to floor, unless they are run either in non-combustible tubing or in a fire-proof shaft having fire stops at each floor.

4. Signal wires and supply wires may run in the same shaft, provided that one of these classes of wires is run in non-combustible tubing, or provided that when run otherwise these two classes of wires shall be separated from each other by at least two inches.

5. In no case shall signal wires be run in the same tube or terminate in the same box with supply wires.

Note: Boxes provided with metal barriers separating the signal from the supply wires will be acceptable, provided each compartment has its own cover.

(k) *Transformers and Other Devices.*

1. Transformers or other devices for supplying current to signaling system from light, heat or power circuits shall be of a design which will adequately protect the signaling system.

2. The primary wiring shall be installed in accordance with the rules for electric light and power inside wiring (Section 134) and the secondary wiring in accordance with the orders of this section.

Order 1392. Other Protective Requirements for Equipment Connected to Signal Circuits Exposed to Supply Lines or Lightning.

(a) *Guarding Noncurrent-Carrying Parts.*

1. Where telephone or other signal apparatus (not included under a-2 below) which must be handled by persons, is permanently connected to overhead signal circuits exposed to lightning or to supply lines over 400 volts to ground, provision against shock to persons handling apparatus shall be made by one of the following methods:

(I) The use of suitable protective devices, such as fuses and arresters, and also for conditions of unusual exposure, drainage coils or transformers or both.

(II) 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.)

(III) The arrangement of apparatus (on signal 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.

Exception: Portable telephones need not be so protected.

2. Such signaling devices as fire and police alarm boxes and telegraph test boxes, if connected to overhead signal circuits exposed to lightning or to supply lines over 400 volts to ground, shall have the accessible noncurrent-carrying metal parts permanently grounded wherever the character of service gives valid objection to the use of arresters or transformers on the signal circuit. (See also b-3 below.)

Note: Police alarm signals, 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. 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 circuit is exposed up to 7500 volts.

(b) *Guarding Current-Carrying Parts.*

1. Telephone or other signaling 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 breakdown of insulation under the prevailing atmospheric conditions.

Note: The inclosing cases of signal apparatus provide suitable guards if substantially built of metal or insulating materials.

2. Under the conditions of (1) above, 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.

3. Where no protective device is installed (permissible only for fire alarm or similar apparatus or for apparatus not for public use, where the character of the service precludes the use of arresters and fuses) the shields of cords shall always be of grounded metal or of special insulating material suitable to withstand the highest supply circuit voltage to which the signal circuit is exposed up to 7500 volts. (See also a-2 above.)

(c) *Protection Against Induced Voltages.*

1. All telephone or other signaling equipment, which must be handled by persons and which is connected to a line that parallels a supply line in such manner that by reason of exposure to the supply line under normal operating conditions more than 150 volts are induced between the terminals of the signaling equipment and ground, shall be protected by one or more of the following methods:

(I) All exposed metal parts of the equipment shall be insulated from the circuit, and the circuit shall be protected by arresters having a breakdown 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.

(II) All exposed noncurrent-carrying metal parts shall be permanently grounded and all current-carrying metal parts shall either be permanently grounded or adequately shielded. (See b above.)

(III) All equipment shall be so located that persons coming in contact with the equipment shall be obliged to stand either on an insulated platform or in a booth of suitable insulating material.

Order 1393. Wiring of Radio Signaling Apparatus.

In setting up radio signaling apparatus all wiring pertaining thereto shall conform to the other provisions of this code that apply for the class of work installed and to the following additional requirements: (See also Order 1300.)

Order 1394. Requirements for Radio Stations Which Receive Only.

(a) *Antenna.*

(1) Antennae outside of buildings shall not cross over or under electric light or power wires of any circuit of more than 250 volts nor shall it be so located that a failure of either antenna or of the above mentioned electric light or power wires can result in a contact between the antenna and such electric light or power wires.

(2) Antennae shall be constructed and installed in a strong and durable manner and shall be so located as to prevent accidental contact with light and power wires by sagging or swinging.

(3) Splices and joints in the antenna span, unless made with approved clamps or splicing devices, shall be soldered.

Exception: Antenna installed inside of buildings are exempted from all of the above requirements.

(b) *Lead-in Wires.*

(1) Lead-in wires shall be of copper, copper-clad steel or other metal which will not corrode excessively.

(2) Lead-in wires shall not be smaller than No. 14 A. W. G.

Exception: Copper-clad steel wire of No. 17 A. W. G. or larger may be used.

(3) Lead-in wires on the outside of buildings shall not come nearer than four inches to electric light and power wires unless separated therefrom by a continuous and firmly fixed nonconductor that will maintain permanent separation. The nonconductor shall be in addition to any insulation on the wire.

(4) Lead-in wires shall enter building through a non-combustible, non-absorptive insulating bushing.

(c) *Protective Device.*

(1) Each lead-in wire shall be provided with an effective protective device properly connected and located (inside or outside the building) as near as practicable to the point where the wire enters the building. The protector shall be isolated from easily ignitable materials or explosives, inflammable flyings or gases.

Note: (1) An effective protective device under this order would be a lightning arrester which will operate at a potential of five hundred (500) volts or less.

(2) The use of an antenna grounding switch, which when in its closed position forms a shunt around the protective device, is recommended. This switch should not have a slate base.

(d) *Disconnecting Switch.*

A switch for disconnecting the receiving apparatus from the antenna shall be provided.

Note: This should preferably be a double pole switch which will disconnect the apparatus from both the antenna and ground connection.

(e) *Protective Ground Wire.*

(1) The ground wire shall be of copper or copper-clad steel. If of copper the ground wire shall be not smaller than No. 14 A. W. G. and if of copper-clad steel it shall be not smaller than No. 17 A. W. G. The ground wire shall be run in as straight a line as possible to a permanent and effective ground. Preference shall be given water piping. Gas piping shall not be used for grounding protective devices.

Note: (1) Other permissible grounds are grounded steel frames of buildings or other grounded metallic work in the building and artificial grounds, such as driven pipes, plates, cones, etc.

(2) The ground wire may be bare or insulated.

(2) The ground wire shall be protected against mechanical injury.

(3) An effective ground clamp shall be used wherever the ground wire is connected to pipes or piping.

(f) *Wires Inside Buildings.*

Wires inside buildings shall be securely fastened in a workmanlike manner and shall not come nearer than two inches to any electric light or power wire unless separated therefrom by some continuous and firmly fixed nonconductor making a permanent separation. This nonconductor shall be in addition to any regular insulation on the wire.

Note: Porcelain tubing or approved flexible tubing may be used for encasing wires to comply with this rule.

(g) *Receiving Equipment Ground Wire.*

(1) The ground conductor shall be of copper, copper-clad steel or other metal which will not corrode excessively under existing conditions.

Note: This conductor may be either bare or insulated and may be run inside or outside of building.

(2) The ground conductor shall not be smaller than No. 14 A. W. G.

Exception: Copper-clad steel wire of No. 17 A. W. G. or larger may be used.

(3) Receiving equipment ground wire may not be used as the ground conductor for the protective device unless it is installed in the manner required by (e) above.

Order 1395. Requirements for Radio Transmitting Stations.

(a) *Antenna.*

Antennae outside of buildings shall conform to the requirements of Order 1394—a.

(b) *Lead-in Wires.*

(1) Lead-in wires shall be of copper, copper-clad steel or other metal which will not corrode excessively.

(2) Lead-in wires shall not be smaller than No. 14 A. W. G.

(3) Antenna and counterpoise conductors and wires leading therefrom to ground switch, where attached to buildings, shall be firmly mounted five inches clear of the surface of the building, on non-absorptive insulating supports such as treated wooden pins or brackets equipped with insulators having not less than five inch creepage and air gap distance to inflammable or conducting material.

Note: Where desired approved suspension type insulators may be used.

(4) In passing the antenna or counterpoise lead-in into the building, a tube or bushing of non-absorptive insulating material shall be used and shall be installed so as to have a creepage and air-gap distance of at least five inches to any extraneous body. If porcelain or other fragile material is used it shall be installed so as to be protected from mechanical injury.

Note: A drilled window pane may be used in place of bushing, provided five (5) inch creepage and air-gap distance is maintained.

(c) *Protective Grounding Switch.*

(1) A double-throw knife switch having a break distance of four inches and a blade not less than one-eighth by one-half inch shall be used to join the antenna and counterpoise lead-ins to the ground conductor.

Note: This switch may be located either inside or outside of the building.

(2) The base of the switch shall be of non-absorptive, insulating material.

Note: Slate base switches should not be used.

(3) This switch shall be so mounted that its current-carrying parts will be at least five inches clear of the building wall or other conductors and located as nearly as possible in a direct line between the lead-in conductors and the point where ground connection is made.

(d) *Protective Ground Wire.*

(1) Antenna and counterpoise conductors shall be effectively grounded at all times when the station is not in actual operation (unattended) by a conductor at least as large as the lead-in and in no case smaller than No. 14 A. W. G. copper or copper-clad steel.

(2) The ground conductor from grounding switch to ground connection shall be securely supported and run to the same type

of ground connection and in the same manner as required by Order 1394—e.

Note: Ground conductor need not be insulated nor mounted on insulating supports.

(e) *Operating Ground Wire.*

(1) The radio operating ground conductor shall be of copper strip not less than three-eighths inch wide by one sixty-fourth inch thick, or of copper or approved copper-clad steel wire having a periphery or girth (around the outside) of at least three-quarters inch (for example, a No. 2 A. W. G. copper wire).

(2) The radio operating ground conductor shall be firmly secured in place throughout its length and protected and supported in the same manner as required for lead-in conductors by Order 1394—b.

(f) *Operating Ground.*

(1) The operating ground conductor shall be connected to a permanent and effective ground.

(2) This ground and ground connection shall conform to Order 1394—e.

(g) *Power from Street Mains.*

(1) When the current supply is obtained directly from street mains, the circuit shall be installed in metal conduit, armored cable or metal raceways.

(2) If lead covered wire is used it shall be protected throughout its length in metal conduit or metal raceways.

(h) *Protection from Surges.*

(1) In order to protect the supply system from high-potential surges and kick-backs there shall be installed in the supply line as near as possible to each radio-transformer, rotary spark gap, motor in generator sets and other auxiliary apparatus one of the following:

1. Two condensers (each of not less than one-half microfarad capacity and capable of withstanding a 600 volt test) in series across the line and 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 across the line with the mid-point grounded.
3. Non-inductively wound resistors connected across the line with mid-point grounded.
4. Electrolytic lightning arresters such as the aluminum cell type.

(2) In no case shall the ground wire of surge and kick-back protective devices be run parallel with the operating ground wire when within a distance of thirty feet.

(3) The ground wire of the surge and kick-back protective devices shall not be connected to the operating ground or its ground wire.

(i) *Suitable Devices.*

Transformers, voltage reducers, keys, and other devices employed shall be of types suitable for radio operation.

APPENDICES OF PART 3

Appendix C. Determining Required Size of Conduit.

For combinations of wire not shown in Tables 1, 2 and 2A of Order 1331 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 IN 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 D. Motor Wiring Tables.

1. *Alternating Current Motors.*

To assist those responsible for the selection of the proper sizes of wires and the proper sizes of fuses or circuit breakers for protecting the wires to a single alternating-current motor, operating under normal conditions, wiring tables are given herewith.

The tables* are based on the following assumptions as to size of fuse required to withstand the starting current without blowing:

Type of Motor	Times Full Load Current at Starting
Single-phase, repulsion-induction; without rheostat	3.00
Single-phase, repulsion-induction; with rheostat	2.00
Single-phase, split-phase (thrown directly across line)	3.00
Poly-phase, slip-ring wound rotor	1.25
Poly-phase, squirrel-cage (with approved auto-starter)	2.00–2.5
Poly-phase, squirrel-cage (thrown directly across line)	3.00

The current values used in these tables are the average current values of motors of different types, all frequencies and standard speeds. Therefore, a variation of 10 per cent higher or lower may be expected. For slow speed motors (less than 700 r. p. m.), wire or cable one size larger than size given in tables will, in the majority of cases, meet the requirements. Voltage drop is not taken into consideration in these tables. Therefore, where long runs are involved wire sizes must be sufficiently increased to limit drop to a safe amount.

*These tables (1–5, inclusive), were prepared by the Committee on Installation and Operation of Induction Motors of the Western Association of Electrical Inspectors.

TABLE 1—SINGLE-PHASE (SPLIT-PHASE TYPE) INDUCTION MOTORS

H. P.	Full Load Amperes		Starting Fuse Amperes		Running Fuse Amperes		Size of Wire or Cable **Rubber, Varnished Cloth or Other Insulation	
	110 V.	220 V.	110 V.	220 V.	110 V.	220 V.	110 V.	220 V.
* ½	6.8	3.4	20	10	10	5	12	14
*1	14	7	40	20	20	10	8	12
*2	24	12	70	40	30	15	6	8
*3	34	17	100	50	45	20	3	8
*5	53	26	160	80	65	35	0	5
*7½	84	42	250	125	100	50	000	2
*10	108	54	325	160	135	70	0000	2

*Motor thrown directly across line; no resistance starter used.
**Varnished cloth insulated wires smaller than No. 6 may not be used.

TABLE 2—SINGLE-PHASE (REPULSION-INDUCTION TYPE) INDUCTION MOTORS

H. P.	Full Load Amperes			Starting Fuse Amperes			Running Fuse Amperes			Size of Wire or Cable **Rubber, Varnished Cloth or other Insulation		
	110 V.	220 V.	440 V.	110 V.	220 V.	440 V.	110 V.	220 V.	440 V.	110 V.	220 V.	440 V.
* ½	6.8	3.4	1.7	20	10	10	10	10	5	12	14	14
*1	12	6	3	35	20	10	15	10	5	8	12	14
*2	23	12.5	6.2	70	35	20	30	15	10	6	8	14
*3	32	16	8	100	50	25	40	20	10	3	8	12
*5	51.6	26	13	150	80	40	65	35	20	1	5	8
7½	76.7	38	19	160	90	50	100	50	25	0	4	8
10	98	49	25	200	100	65	125	65	35	00	3	6
15	141	70	35	280	140	75	180	90	50	200,000	1	5
20	198	100	50	400	200	100	250	125	65	300,000	0	3
25	.....	120	60	.....	240	120	.....	150	75	.....	000	2
30	.....	146	73	.....	300	150	.....	180	90	.....	200,000	1
40	.....	197	98	.....	400	200	.....	250	125	.....	300,000	0
50	.....	234	117	.....	470	240	.....	290	150	.....	400,000	000

*Motor thrown directly across line; no resistance starter used.
**Varnished cloth insulated wires smaller than No. 6 may not be used.

TABLE 3
TWO-PHASE (4-WIRE) SQUIRREL-CAGE INDUCTION MOTORS

H. P.	† Full Load Amperes				Starting Fuse Amperes				Running Fuse Amperes				‡ Size of Wire or Cable Rubber, Varnished Cloth or Other Insulation			
	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.
*1	6.4	3.2	1.6	1.2	20	10	10	10	10	5	5	5	14	14	14	14
*2	11	5.7	2.9	2.3	30	20	10	10	15	10	5	5	10	14	14	14
*3	16	8.1	4.1	3.2	50	25	15	10	20	10	5	5	8	12	14	14
*5	26	13	6.5	5.3	80	40	20	20	35	15	10	10	5	8	12	12
7½	38	19	9.5	7.8	80	50	25	25	40	25	15	10	5	8	12	12
10	44	22	11	10	90	55	30	30	55	30	15	15	4	6	10	10
15	66	33	16.5	15	130	65	40	40	85	40	20	20	1	6	8	8
20	88	44	22	19.5	175	90	60	50	110	55	30	25	0	4	6	8
25	111	55	28	23.4	225	110	70	60	140	70	35	30	00	2	6	6
30	134	67	33.5	27.6	275	140	70	70	180	85	40	35	000	1	6	6
40	178	89	44	36.4	350	180	90	80	220	110	55	45	250,000	0	4	5
50	204	102	51	45	400	210	100	90	255	130	65	55	300,000	00	2	2
75	308	154	77	66.5	600	300	150	140	375	200	95	85	500,000	200,000	1	1
100	.....	204	102	87	.....	400	200	180	.....	250	130	110	.....	300,000	0	0
150	.....	308	154	128	.....	620	300	260	.....	385	200	160	.....	550,000	200,000	000
200	.....	409	204	169	.....	820	400	340	.....	510	250	210	.....	800,000	300,000	250,000
250	.....	510	250	207	.....	1,020	500	420	.....	610	310	260	.....	1,100,000	400,000	350,000
300	.....	600	300	246	.....	1,200	600	500	.....	750	375	300	.....	1,300,000	500,000	400,000

THREE-PHASE (3-WIRE) SQUIRREL-CAGE INDUCTION MOTORS

*1	7.4	3.7	1.9	1.3	25	10	10	10	10	10	5	5	12	14	14	14
*2	13	6.6	3.3	2.5	40	25	15	10	15	10	5	5	8	12	14	14
*3	19	9.3	4.7	3.5	60	30	20	15	25	15	5	5	6	10	14	14
*5	30	15	7.5	6	90	45	25	20	40	20	10	10	4	8	12	14
7½	44	22	11	9	90	60	30	25	55	30	15	15	4	6	10	12
10	50	25	12.5	11	100	65	35	30	65	30	15	15	3	6	8	10
15	76	38	19	16	150	80	50	40	90	50	25	20	1	5	8	8
20	102	51	25.5	22	200	100	65	60	130	65	30	30	0	3	6	6
25	129	64	32	25	260	130	70	65	160	80	40	35	000	1	5	6
30	154	77	38.5	32	300	160	80	75	200	100	50	40	200,000	0	4	5
40	204	107	53.5	44	400	220	110	90	250	135	65	55	300,000	00	2	4
50	236	118	59	52	480	240	120	100	300	150	75	65	500,000	000	1	3
75	356	178	89	77	710	360	180	150	400	225	110	100	650,000	300,000	0	1
100	.....	236	118	100	.....	470	240	200	.....	300	150	125	.....	400,000	000	0
150	.....	355	178	147	.....	710	360	300	.....	450	225	185	.....	650,000	300,000	200,000
200	.....	470	235	192	.....	940	470	400	.....	600	300	240	.....	950,000	400,000	300,000
250	.....	590	290	237	.....	1,180	580	480	.....	740	360	300	.....	1,250,000	500,000	400,000
300	.....	700	350	285	.....	1,400	700	570	.....	875	440	360	.....	1,600,000	650,000	500,000

*Motor thrown directly across line; no auto-starter used.
†Value of current in common wire for two-phase three-wire system would be 1.41 times values given.
‡Varnished cloth insulated wires smaller than No. 6 may not be used.

TABLE 4
TWO-PHASE (4-WIRE) WOUND ROTOR INDUCTION MOTORS

H. P.	Full Load Amperes		Fuse Size Amperes		Size of Wire or Cable: Rubber Insulation		Varnished Cloth Insulation*		Other Insulation	
	220 V.	440 V.	220 V.	440 V.	220 V.	440 V.	220 V	440 V.	220 V.	440 V.
5	13	6.5	20	10	12	14			14	14
7½	20	10	25	15	10	14			12	14
10	25	12.5	35	20	8	12			10	14
15	35	18	45	25	6	10	6		8	12
20	48	24	60	30	4	8	6		6	10
25	54	27	70	35	4	8	4		6	8
30	70	35	90	45	2	6	3	6	4	8
35	81	40	110	50	1	6	2	6	2	8
40	95	47	120	60	0	4	1	6	2	6
50	110	55	140	70	00	4	0	4	1	6
75	165	83	200	100	200,000	1	000	2	0	3
100	215	108	270	135	300,000	00	0000	0	000	1
150	320	160	400	200	500,000	200,000	400,000	000	300,000	0

THREE-PHASE (3-WIRE) WOUND ROTOR INDUCTION MOTORS

H. P.	Full Load Amperes			Fuse Size Amperes			Size of Wire or Cable: Rubber Insulation			Varnished Cloth Insulation*			Other Insulation		
	220 V.	440 V.	550 V.	220 V.	440 V.	550 V.	220 V.	440 V.	550 V.	220 V.	440 V.	550 V.	220 V.	440 V.	550 V
5	15	7.5	6	20	10	10	12	14	14				14	14	14
7½	22	11	9	30	15	15	10	14	14				10	14	14
10	29	14	11	40	20	15	8	12	14				8	14	14
15	41	20	16	50	25	20	6	10	12	6			8	12	12
20	55	27	22	70	35	30	4	8	10	6			6	8	10
25	62	31	25	80	40	35	3	6	8	4			5	8	8
30	81	40	32	100	50	40	1	6	6	3	6		3	8	8
35	94	47	37	125	60	50	0	4	6	2	6	6	2	6	8
40	109	54	44	140	75	55	00	4	5	1	4	6	1	6	6
50	127	64	52	160	80	65	000	3	4	0	4	5	0	5	6
75	192	96	77	240	120	100	250,000	0	1	000	1	2	000	2	3
100	248	120	100	310	160	125	400,000	000	0	0000	00	1	0000	0	2
150	366	183	147	450	230	175	600,000	250,000	000	450,000	200,000	00	350,000	000	0

*Varnished cloth insulated wires smaller than No. 6 may not be used.

TABLE 5

TWO-PHASE (4-WIRE), 2,200-VOLT INDUCTION MOTORS

H. P.	Full Load Amps.	Size of Starting Protection Amps.	Size of Running Protection Amps.	Size of Wire or Cable Rubber or Varnished Cloth Insulation*
5	1.38	5	3	14
7½	2.08	10	5	14
10	2.6	10	5	14
15	3.8	10	5	14
20	5.2	15	10	14
25	6.2	20	10	14
35	8.65	25	15	12
40	9.8	25	15	12
50	12.1	30	15	10
75	17.3	35	20	8
100	22.8	60	30	6
150	33.2	65	40	6
200	43.5	85	45	4
250	54	110	65	2
300	64	130	80	1

THREE-PHASE (3-WIRE), 2,200-VOLT INDUCTION MOTORS

H. P.	Full Load Amps.	Size of Starting Protection Amps.	Size of Running Protection Amps.	Size of Wire or Cable Rubber or Varnished Cloth Insulation*
5	1.6	5	3	14
7½	2.4	10	5	14
10	3	10	5	14
15	3.8	10	5	14
20	5.1	15	10	14
25	6.4	15	10	14
35	9.4	25	15	12
50	14	35	20	8
75	20	50	25	8
100	25.8	65	30	6
150	38.9	75	50	5
200	52	100	65	3
300	72.5	150	90	1
400	96.6	200	120	0
500	121	250	150	000
600	145	300	175	200,000
750	182	360	225	300,000

*Varnished cloth insulated wires smaller than No. 6 may not be used.

The carrying capacity of a wire as given in Tables 3 and 3-A, Order 1341—a-1, Section 134, Part 3 of the code, is based on the assumption that the conductor will carry its rated current indefinitely and in so doing will not rise in temperature above a predetermined safe value. However, where the current flows only for a short period of time as in the operation of elevators, cranes, spot welders, etc., the current-carrying capacity of conductors, as given in the code, can be safely increased. The current-carrying capacities which have been found safe for different periods of time are given in the accompanying table for all common sizes of wire. Table 6* is based on the use of three rubber-covered wires in conduit, with an ambient temperature of not more than 85° F. (35° C.), and for other installations at ambient temperatures ranging from 85° to 125° F. (35° to 52° C.). Sufficient time must be allowed between the application of current to permit the conductors to cool down to the ambient temperature.

TABLE 6—CURRENT-CARRYING CAPACITY OF CONDUCTORS FOR INTERMITTENT SERVICE

A. W. G.	Size Conduit for Three Conductors In.	Code		Carryng Capacity, Amp., for 36 Deg. Fahr. Rise				
		Carrying Capacity, Amp.	Actual Temp. Rise, Deg. Fahr.	Indefinite Time	Short Time in Minutes			
					30	15	10	5
14	½	15	27.0	17	19	22	24	30
12	¾	20	31.0	22	24	26	29	35
10	¾	25	27.9	27	30	35	40	45
8	1	35	29.9	36	43	50	60	65
6	1	50	33.1	52	60	73	80	105
5	.....	55	.....	56	69	88	100	125
4	1¼	70	40.7	64	77	97	110	140
3	1¼	80	34.9	82	93	113	135	165
2	1½	90	34.7	90	106	130	155	195
1	1½	100	39.1	96	126	154	180	225
0	2	125	41.2	110	147	182	210	275
2-0	2	150	41.8	130	179	220	260	340
3-0	2	175	39.4	150	213	270	320	420
200,000	.....	200	.....	175	247	310	355	480
4-0	2½	225	57.6	180	256	325	395	515
250,000	.....	240	.....	205	297	375	455	585
300,000	3	275	45.2	238	345	435	535	690
350,000	.....	300	.....	265	395	500	605	790
400,000	3	325	42.1	290	440	555	690	850
500,000	3	400	48.1	345	529	660	800	1,090
600,000	.....	450	.....	390	610	750	915	1,225
700,000	.....	500	.....	430	680	830	1,025	1,400
750,000	4	525	44.8	450	710	870	1,080	1,450
800,000	.....	550	.....	465	745	905	1,120	1,525
900,000	.....	600	.....	495	810	975	1,210	1,665
1,000,000	4½	650	55.2	525	870	1,040	1,295	1,800

* By Victor H. Tousley.

There appears to be no fixed ratio that may apply to current values in stator and rotor circuits of the wound rotor slip-ring type of motor, but the current values in both the stator and rotor circuits are now indicated on the name plate of the motor. In selecting wire sizes for leads between resistance grids and slip-rings be guided by the current value of the rotor circuit, and the safe carrying capacity of Tables 3 and 3-A, Order 1341—a-1, Section 134, Part 3 of Code.

2. *Direct Current Motors.*

Although the calculations for wire sizes for direct-current motors are more readily and more quickly made on the job, a similar table of wire sizes to supply a single direct-current motor is very convenient and is here given:

TABLE 7*—DIRECT-CURRENT MOTORS

H. P.	Full Load Running Current			Fuse Capacity Amperes			Size of Wire or Cable See Note		
	110 V.	220 V.	550 V.	110 V.	220 V.	550 V.	110 V.	220 V.	550 V.
½	4.5	2.3	1	10	5	5	14	14	14
1	9	4.5	1.5	10	10	5	14	14	14
2	17	8.5	3.5	25	15	5	10	14	14
3	24.5	12.5	5	35	20	10	8	12	14
5	40	20	8	50	25	15	6	10	14
7½	59	29	11.5	70	35	15	4	8	14
10	78	39	15.5	100	50	20	1	6	12
12½	95	48	20	125	70	25	0	4	10
15	116	58	23	150	70	30	000	4	8
20	156	78	31	200	90	50	200,000*	2	6
25	192	96	38	225	125	50	0000	0	6
30	230	115	46	275	150	70	300,000	00	4
35	267	133	53	325	175	70	400,000	000	4
40	304	152	61	400	200	80	500,000	200,000	3
50	378	185	76	450	225	90	600,000	0000	2
100	748	374	150	900	450	200	1,700,000	600,000	200,000

Note: Rubber, varnished cloth or other insulation. Varnished cloth wires smaller than No. 6 may not be used.

3. *Size of Wires for a Group of Motors.*

The maximum horse-power that should be grouped upon any mains or branches supplying a group of motors is given in the following table:

*Prepared by Wisconsin Inspection Bureau.

TABLE 8*

SIZE OF WIRE A. W. G.	Direct-Current Motors Maximum Permissible H. P.		Three Phase A. C. Motors Maximum Permissible H. P.	
	110 V.	220 V.	220 V.	440 V.
14	2	4	6	12
12	2.7	5.3	8	16
10	3.3	6.7	10	20
8	4.7	9.3	14	27
6	6.7	13.3	20	39
4	9	19.0	27	55
3	11	21	31	62
2	12	24	35	70
1	13	27	39	78
0	17	33	49	97
00	20	40	59	117
000	23	47	68	137
0000	30	60	88	176
250,000 c. m.	33	67	97	195
300,000 c. m.	37	73	108	216
350,000 c. m.	40	80	117	234
400,000 c. m.	43	87	127	254
500,000 c. m.	53	106	156	312
600,000 c. m.	60	120	176	352
700,000 c. m.	67	133	195	390
800,000 c. m.	73	147	215	430
900,000 c. m.	80	160	234	468
1,000,000 c. m.	87	173	254	508
1,100,000 c. m.	92	184	269	539
1,200,000 c. m.	97	195	285	570
1,300,000 c. m.	103	205	301	602
1,400,000 c. m.	108	216	316	633
1,500,000 c. m.	113	227	332	664
1,600,000 c. m.	119	237	348	695
1,700,000 c. m.	124	248	363	727
1,800,000 c. m.	129	259	378	757
1,900,000 c. m.	135	269	394	789
2,000,000 c. m.	140	280	410	820

*Prepared by Department of Gas and Electricity of the City of Chicago.

Appendix E. Extracts From Building Code

PART III—GENERAL REQUIREMENTS.

SECTION 10—LIGHTS.

Order 5224. Oil lamps shall not be used when gas or electricity is available, except in private apartments.

Gas and oil lights shall be placed at least 6 feet above the floor level, at least 6 inches from any combustible partition or wall, and at least 2 feet (measured from top of flame) below any combustible ceiling unless properly protected by a metal shield with at least 2 inches of air space above. Swinging brackets shall be provided with a guard or stop so that the light cannot come nearer to the partition or wall than one foot. In aisles and public passageways, every such light shall be protected by an incombustible guard unless the light is at least 6 feet above the floor.

Note: Especial care should be taken to prevent curtains or draperies from coming into contact with a flame. Gas and oil lights should be kept at least two feet away from any door or window where curtains are used.

Every gas supply main shall have a service cock outside of the building, so placed and maintained that it can be shut off at any time without entering the building.

See also Orders 5410, 5529—31, 5715.

Note: Most large cities now require a specially, designed cock which does not become clogged with rust or ice, and which can easily be located and shut off by the firemen. This is very desirable, as many small fires have become serious through the breaking of gas pipes in the building.

SECTION 11—ELECTRICAL WORK.

Order 5225. All electrical work shall conform to the Wisconsin State Electrical Code, comprising General Orders 1000–1499, inclusive, of the Industrial Commission.

Order 5255. Artificial Light. Every toilet room (except in a private apartment) shall be artificially lighted during the entire period that the building is occupied, wherever and whenever adequate natural light is not available, so that all parts of the room are easily visible.

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 op-

erated 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 F. Dry Cleaning Establishments

Statutory regulation of the wiring of new dry cleaning establishments is contained in Section 167.21, subsection 2, paragraph (i) of the Wisconsin Statutes for 1923, which reads as follows:

"(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 G. 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 H. 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 I. 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 J. 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 K. Extracts From General Orders on Existing Buildings

Order 2062—Equipment.

(1) **Electrical Equipment.** Electrical equipment other than lamps and the necessary wiring for lamps shall not be installed within the booth, and all equipment supplying electrical energy to such booth for mechanical, chemical, heating, lighting or similar purposes shall be installed, operated and maintained in accordance with all of the requirements of the Wisconsin State Electrical Code. Wiring to lamps within such booths shall be in rigid metal conduit.

(2) **Grounding.** All exposed non-current carrying metal parts of electrical equipment serving such booths, and all metal parts of the booths themselves, unless only ceramics are used, 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 used, be similarly grounded to prevent accumulation of static charges of electricity.

(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. If lamps are installed within the booth they shall be enclosed in vapor-proof globes, except when ceramics only are used.

PART 4

Safety Measures to Be Observed in the Operation of Electrical Equipment and Lines

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PART 4

Safety Measures to Be Observed in the Operation of Electrical Equipment and Lines

SECTION 140. GENERAL REQUIREMENTS

(To be Observed by All Employers of Electrical and Signal Workmen.)

Order 1400. Qualifications of Employes.

The employer shall use every reasonable means and precaution to assure himself that each employe is mentally and physically qualified to perform his work in accordance with these rules. No employe shall be permitted to do work upon or in proximity to dangerous live electrical lines or equipment, or in such position as to permit of the establishment of contact, unless he is properly qualified or is under the direct supervision of an experienced and qualified person.

Workmen whose employment incidentally brings them in the neighborhood of electrical supply equipment or lines with the dangers of which they are not familiar shall always be accompanied by and work under the supervision of a properly qualified and authorized person.

Note: See definition of "Qualified" in Introductory Part, Section 102.

Order 1401. Instructing Employes.

(a) Employes regularly working on or about live electrical equipment or lines shall be thoroughly instructed in methods of first aid, resuscitation and, where necessary, in fire extinguishment.

(b) All such employes shall be instructed as to the character of all electrical 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 by position, letter, color, number, or name.

Order 1402. 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 the workmen shall be instructed as to the work they are to perform and the employe instructing the workmen shall be considered in charge of the work.

Order 1403. Attendance.

Unless a properly qualified employe is in constant attendance in rooms where generators and other supply equipment are in operation, such rooms shall be made inaccessible to other than qualified persons.

Order 1404. Requirements for Two Workmen.

Except in trouble or emergency work, at least two employes shall be provided where work is done in wet weather or at night on, or dangerously near, live lines above 750 volts.

Order 1405. Uninstructed Workmen and Visitors.

Unqualified employes or visitors shall be prohibited from approaching any dangerous live parts unless accompanied by a qualified person.

Order 1406. Protective Devices.

(a) There shall be provided in conspicuous and suitable places in electrical stations, telephone exchanges, testing departments, and line construction and repair wagons, a sufficient supply of suitable protective, first aid, and fire extinguishing devices and equipment, to enable employes to meet the requirements of these orders. Such devices and equipment shall be periodically inspected or tested to insure that they are kept in good order. Safety belts and similar equipment, whether furnished by employer or employe, shall be inspected from time to time to assure that they are in safe working condition.

(b) Employes that work on or near dangerous live parts shall be required by the operating rules (see Order 1410) to use the protective devices and the special tools provided, first examining them to make sure that these devices and tools are suitable and in good condition. Employes shall further be required to wear suitable clothing while working on or about dangerous live equipment and lines. When working under these conditions, they shall be warned to keep sleeves down and avoid wearing unnecessary metal or inflammable articles such as rings, watch or key chains,

metal cap visors, celluloid collars or celluloid cap visors, and warned not to wear loose clothing and shoes that slip easily when working near moving parts.

Note: 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) Safety belts and similar equipment.

(2) First aid outfits.

(3) 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.

(4) Protective goggles of suitable materials and construction.

(5) Tools of 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.

(6) "Men at Work," tags, log books, operating diagrams or equivalent devices, and portable danger signs.

(7) Fire extinguishing devices, either designed for safe use on live parts or plainly marked that they must not be so used.

(8) Grounding devices for making protective grounds.

Order 1407. Warning and Danger Signs.

There shall be displayed in conspicuous places at all unattended or unlocked entrances to electrical supply stations, substations and electrical testing rooms containing exposed current-carrying parts or moving parts, permanent warning signs forbidding entrance to unqualified persons. Suitable danger signs shall be placed in supply stations, substations, switching towers and testing rooms about equipment having exposed current-carrying parts above 750 volts.

Order 1408. Safe Supports, Safety Belts and Tools.

(a) *Safe Supports.*

(1) Employes shall be instructed and required not to support themselves on any portion of a tree, pole, structure, scaffold, ladder, or other elevated structure without first making sure that the supports are strong enough, reinforcing them if necessary.

(2) Ladders used on or near dangerous live electrical equipment or lines shall not be painted with conducting paint or reinforced lengthwise with metal.

Note: 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 surfaces are smooth or vibrating. (See also General Orders on Safety.)

(b) *Safety Belts.* Employes shall be instructed and required not to work in elevated positions unless secured from falling by a suitable safety belt or by other adequate means, and to exercise care to see that the snaps or fastenings are properly engaged and that they are secure in their belts before intrusting their weights to the belts.

(c) *Tools and Materials.* Employes shall be instructed and required to take the necessary precautions to avoid dropping tools or materials from elevated positions, and to use hand lines and proper receptacles for raising or lowering them.

SECTION 141. OPERATING RULES

Order 1410. Utilities to Adopt Operating Rules.

(a) All utilities, that regularly employ three or more men, shall adopt and strictly enforce an adequate set of operating rules designed to attain the safety of such employes through the observation of the necessary precautions while at work on or near dangerous live parts.

Note: Since electrical equipment cannot always be completely guarded, the safety of employes must be attained through safe methods of working.

(b) The operating rules adopted shall contain the general requirements of Part 4 of this code, in so far as they apply to the specific plant and work of any utility, and such additional rules as may be necessary to reduce the hazards of operation to a minimum.

(c) Operating rules shall be filed with the Commission within six months of the time these orders take effect.

Note: Filing of operating rules with the Commission will not act as a guarantee that the rules so filed are adequate for the purpose of minimizing operating hazards. In other words, the entire responsibility for the adequacy of the rules adopted lies with the employer.

Order 1411. Distribution and Posting of Operating Rules.

Each employe shall be provided with a printed or typewritten copy of the operating rules or that section of the rules which applies to his work, or such rules shall be posted conspicuously in the office, stations, testing rooms, line wagons, and other work

places of the employer where the number of employes and the nature of the work warrant.

Order 1412. Knowledge of Safety Rules and Reporting Defects.

(a) Employers shall require employes to study and familiarize themselves with the safety rules adopted pursuant to Order 1410 and shall from time to time test their knowledge of the rules as well as their knowledge of approved methods of first aid, resuscitation and fire extinguishment.

Note: It should be the aim of the employer to make his employes safe men so that they will consider the effect of each act when working on or about live equipment and will do nothing which may endanger themselves or others. They should be taught to always place themselves in a safe and secure position, taking all reasonable precautions, including the use of such safety devices as may be necessary.

(b) Employes shall be required to promptly report to their superiors any dangerous conditions of equipment or surroundings, in stations, on overhead or underground lines, of inferior wiring connected to lines, and all features which they note that may endanger life and property.

Order 1413. Organization Diagram.

The employing utility shall prepare and distribute, or post conspicuously, an organization chart or written statement which clearly shows to whom each employe is responsible and what person is in direct charge of each phase of the work down to and including the grade of foreman.

Order 1414. Address List and Emergency Rules.

Each employe whose work is such as to require it shall be furnished with instructions indicating the individual or individuals to be called in case of an emergency, and rules for first aid and rescuscitation and fire extinguishment.

Order 1415. Chief Operator.

Each electrical utility shall place a properly qualified person in charge of the operation of electrical equipment and lines and shall make such qualified person directly responsible for their safe operation.

Note: Such qualified person in charge of operation and safety may be designated chief operator, system operator, load dispatcher, general superintendent or otherwise. 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 employe who shall report as required to the chief. 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 for a portion of the system by a local superintendent, local manager, or other employe who may also perform other duties. In small organizations the duties of the chief operator may be performed by the superintendent, electrician, engineer or some other employe who may also perform other duties.

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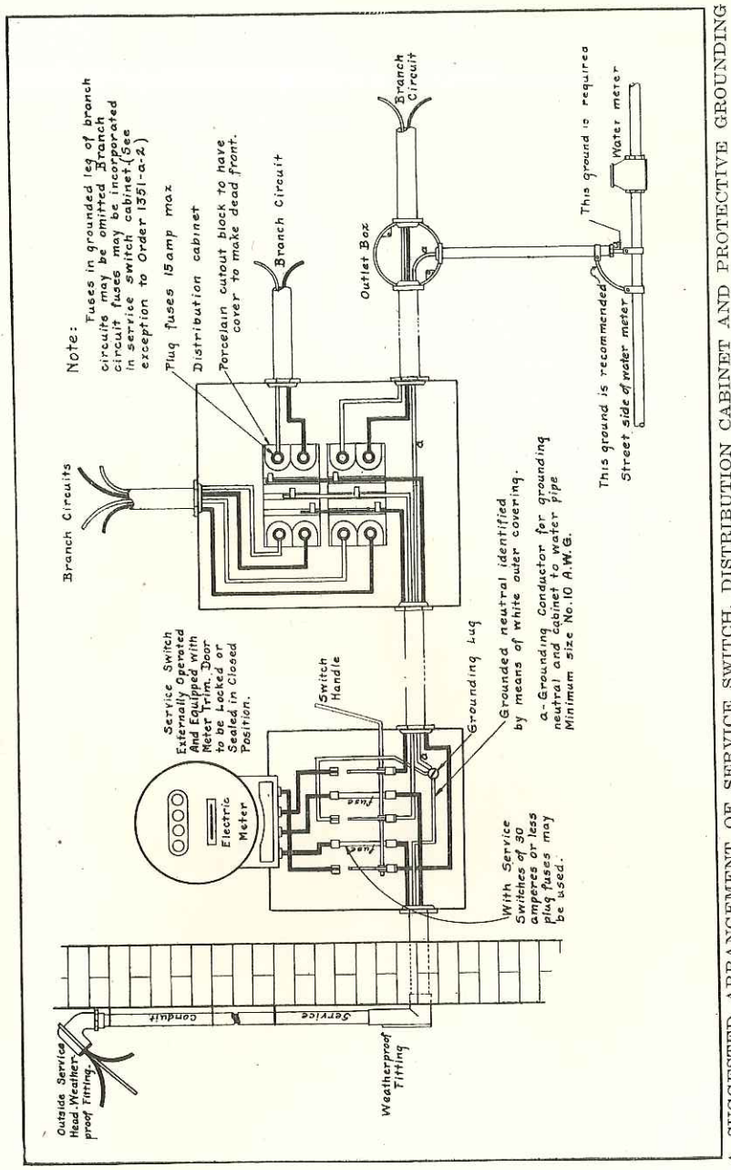

A SUGGESTED ARRANGEMENT OF SERVICE SWITCH, DISTRIBUTION CABINET AND PROTECTIVE GROUNDING CONNECTION.

While the code does not require the service switch to disconnect the service fuses from the source of supply, and the above sketch shows such an arrangement, a service switch in which the switch does operate to disconnect the service fuses is to be preferred. Another superior arrangement is an interlocking type of switch which prevents access to the service fuses while they are alive.