NATIONAL ELECTRICAL SAFETY CODE

FOURTH EDITION

DECEMBER 31, 1926

HANDBOOK SERIES
OF THE
BUREAU OF STANDARDS

No. 3

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

HANDBOOK SERIES OF THE BUREAU OF STANDARDS, No. 3

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American Standard, approved November 15, 1927, by the American Engineering Standards Committee

PRICE $1.00
Sold only by the Superintendent of Documents, U. S. Government Printing Office
Washington, D. C.

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1927

PREFACE

In the preparation and revision of this code the Bureau of Standards has had the cordial cooperation and assistance of many State, industrial, and public service commissions, municipal electrical inspectors, engineers of operating and manufacturing companies, committees of engineering societies, and representatives of the electrical workers and of the fire and casualty insurance interests. Without such cooperation the work would have been impossible. With it, steady progress has been made and the fourth edition more nearly meets the views of the various interests involved, some of which are to a certain extent conflicting, than has been the case in any of the previous editions. The revision of the code for the present edition has been carried out under the rules of procedure of the American Engineering Standards Committee. The work has been done by two separate committees, the membership of which will be found upon pages VII to XIII. One of these committees has dealt with parts 1 and 3 and the grounding rules found in section 9; the other committee has dealt with parts 2 and 4. Both committees have approved the new rules dealing with radio installations found in part 5. The entire code as revised has been approved by the American Engineering Standards Committee as an American Standard.

In the preparation of earlier editions of the code the bureau held meetings in many parts of the country and welcomed suggestions from everyone concerned. It, however, reserved to itself the final decision on all contested points. The procedure followed in the present revision differs essentially from the former practice in that final decisions as to all details have been made by the representative committees formally approved by the American Engineering Standards Committee. The bureau as sponsor for the work under this procedure gives up its prerogative of determining details in return for the implied understanding that the many parties concerned will accept such a code as they can agree upon among themselves. All such codes of practice necessarily include compromises between conflicting aims. The bureau has felt that decisions made by practically unanimous agreement among the interests affected would, in general, be wiser than those at which it might arrive after weighing the arguments of advocates for different views. It has, therefore, welcomed the new procedure, in spite of the fact that this involves the acceptance of some details of which it might not itself approve.

The first complete edition of this code was issued as circular No. 54 of this bureau. Part 4 had already been published separately in 1914 as circular No. 49. A second edition was published in 1916 and had wide distribution for examination, trial, and constructive criticism. This edition received careful study and wide use, and parts of it were adopted by State commissions having appropriate jurisdiction. It was, however, mainly used as a standard of reference for general guidance.

The third edition was issued in 1920 as Handbook No. 3. It has been more widely adopted by administrative authorities, some of whom have applied it verbatim, while others have used it as a basis in formulating local regulations and orders. In one form or another it has been applied in nearly half of the States.

The present edition represents only minor changes in the general substance of the rules. The regulations dealing with line construction probably incorporate more important changes than any of the other parts, since it is this field of construction regarding which the views of operating engineers represent the greatest diversity of opinion. The rules of this part and also of part 4 have been entirely rearranged, and it is thought that the new arrangement will increase the facility of reference and make more clear the intended effect of the requirements.

Part 5, dealing with radio installations, is entirely new in substance and has been prepared to meet a very wide demand for guidance in the installations of both antennas and interior equipment.

This code represents a growth and development which will necessarily continue in the future as in the past. More specific requirements can be worked out with respect to many items covered by the rules, and more definite conclusions can, no doubt, be arrived at in the case of requirements regarding which there is not yet entire agreement. Such points will be the subject of further study not only by the bureau staff but also by representatives of utilities and other interests most seriously concerned with these subjects. If experience or experiment provides sufficient evidence for changing the requirements in future editions it will, of course, be done, and every effort will be made to obtain data and accumulate experience leading to the formulation of modified rules which will meet with even more ready and general acceptance. The code rules specifically provide for variation from particular requirements when circumstances warrant different practice.

The rules have been made to recognize conditions as to climate and density of population where these involve a difference in the hazard or the number of persons exposed to the hazard. This is particularly true of overhead lines.

While such treatment has added a considerable amount of detail to the rules and greatly increases the extent of tables found in the appendixes to part 2, it is considered necessary to properly cover the varied conditions met with in the field.

Rules which are to be regarded as mandatory are characterized by the use of the word "shall." Where a rule is of an advisory nature it is indicated by the use of the word "should." Other practices which are considered desirable and not intended to be mandatory are stated as recommendations. It is realized that conditions may exist which necessitate departures from such recommendations.

Criticism of the rules contained in this edition and suggestions for their improvement are invited and every effort will be made in the preparation for the next edition to perfect the rules both in the development of detail and in the modification of any requirements which it is found can be improved.

A discussion of these rules will be found in a separate volume designated as Handbook No. 4, a new edition of which constitutes a companion volume to this edition of Handbook No. 3.

The preparation of the sag and tension tables and curves found in the appendixes to part 2 has involved a great deal of work owing to the extension of their scope. In this work the bureau has had the assistance of engineers of the Philadelphia Electric Co. and the Copperweld Steel Co. This assistance is gratefully acknowledged. In the rearrangement of parts 2 and 4 and the preparation of revised drafts our thanks are due to the staff of the American Telephone & Telegraph Co. for their extensive assistance.

George K. Burgess,
Director.

December 1, 1926.

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SEC. 1. DEFINITIONS OF SPECIAL TERMS

Alphabetical List of Defined Terms

The following definitions give the meanings of some of the terms occurring in these rules. Terms not defined will be understood to have their usual meanings.

1. **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.

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

This includes generating stations and substations and generator, storage-battery, and transformer rooms, but excludes manholes and isolated transformer vaults on private premises. (See definition 59.)

3. **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.

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.

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

4. **Communication lines** means the conductors and their supporting or containing structures which are located outside of buildings and are used for public or private signal or communication service and which operate at not exceeding 400 volts to ground or 750 volts between any two points of

the circuit and the transmitted power of which does not exceed 150 watts. When operating at less than 150 volts, no limit is placed on the capacity of the system.

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

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

Exception is made under certain conditions for communication circuits used in the operation of supply lines. (See rule 288.)

5. **Minor communication lines** means cummunication lines carrying not more than two circuits used mainly for local telephone or telegraph service, or for police or fire-alarm service.

6. **Minor tracks** means railway tracks included in the following list:

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

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

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

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

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

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

8. **Voltage** or **volts** means the highest effective voltage between any two conductors of the circuit concerned, except that in grounded multiwire circuits, not exceeding 750 volts

between outer conductors, it means the highest effective voltage between any wire of the circuit and the ground.

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

When one circuit is directly connected to another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage, unless the circuit of lower voltage is permanently grounded. Direct connection implies electrical connection as distinguished from connection merely through electromagnetic or electrostatic induction.

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

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

"Effective," as herein used, means a connection to earth of sufficiently low resistance and high current-carrying capacity to prevent any current in the grounding 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.

11. **Permanently grounded** means having such an effective connection to the earth (by use of an underground system of metallic pipe mains or other suitable means), as described in the preceding paragraph.

12. **Guarded** means covered, shielded, fenced, inclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats or platforms, to remove the liability of dangerous contact or approach by persons or objects to a point of danger.

13. **Isolated** means that an object is not readily accessible to persons unless special means for access are used.

14. **Isolation by elevation** means elevated sufficiently so that persons may safely walk underneath.

15. **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 accumulations of flyings or dust nor transmit sparks or flying particles to the accumulations outside.

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

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

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

18. **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.

When any object is said to be insulated, it is undertsood to be insulated in 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 for making the conductors insulated.

19. **Insulating** (where applied to the covering of a conductor, or to clothing, guards, rods, and other safety devices) means that a device, when interposed between a person and current-carrying parts, protects the person making use of it against electric shock from the current-carrying parts

with which the device is intended to be used; the opposite of conducting.

20. **Conductor** means a metallic conducting material, usually in the form of a wire or cable, suitable for carrying an electric current. Does not include bus bars.

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

22. **Current-carrying part** means a part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

23. **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.

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

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

26. **Open wires** means overhead wires not in conduits, and consisting of single or paired conductors as opposed to multiple-conductor cables.

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

28. **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.

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

30. **Manual** means capable of being operated by personal intervention.

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

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

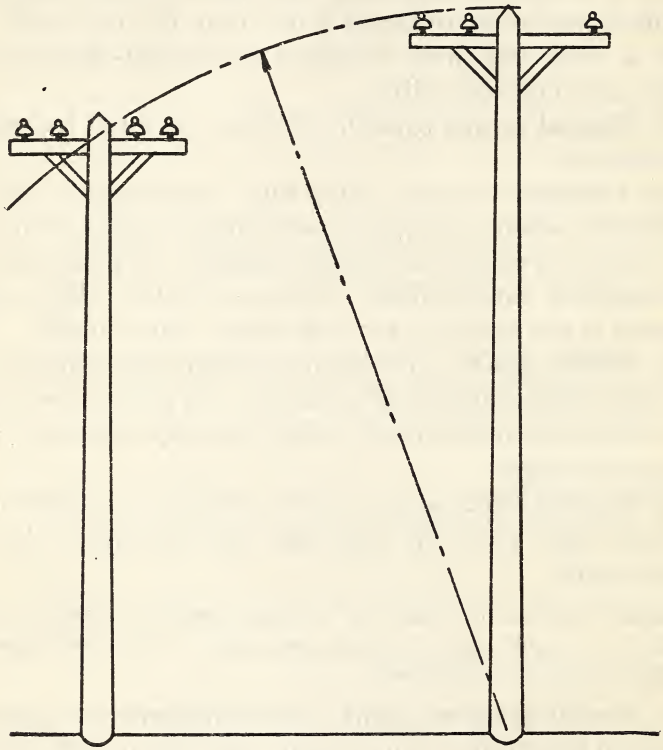
33. **Disconnector** means a switch which is intended to open a circuit only after the load has been thrown off by some other means.

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

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

35. **Switchboard** means a large single panel, frame or assembly of panels on which are mounted (on the face, or back, or both) switches, fuses, busses, and usually instruments.

36. **Panelboard** means a single panel containing busses, fuses, and switches to control lights, fan motors, and similar devices of small individual as well as aggregate capacity, placed in or against a wall or partition and accessible only from the front



Structure Conflict

37. **Qualified** means familiar with the construction and operation of the apparatus and the hazards involved.

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

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

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

41. **Explosion-proof** means capable of withstanding without injury and without transmitting flame to the outside any explosion of gas which may occur within.

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

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

(1) Where one line crosses another.

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

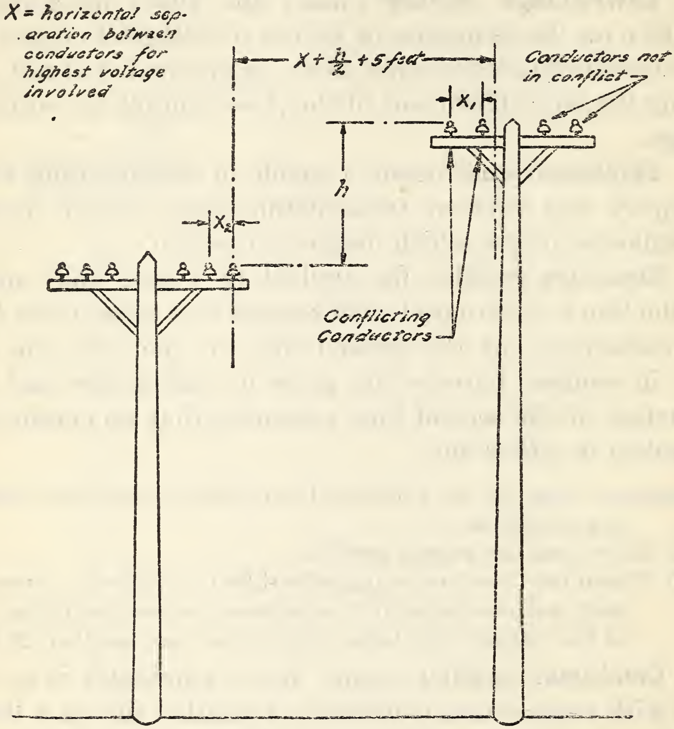
43. **Conductor conflict** means that a conductor is so situated with respect to a conductor of another line at a lower level that the horizontal distance between them is less than the sum of the following values:

(*a*) Five feet.

(*b*) One-half the difference of level between the conductors concerned.

(*c*) The value required in Table 6, 7, or 8 for horizontal separation between conductors on the same support for the highest voltage carried by either conductor concerned.

44. **Antenna conflict** means that an antenna or its guy wire is at a higher level than a supply or communication conductor and approximately parallel thereto, provided the breaking of the antenna or its support will be likely to result



Conductor Conflict

in contact between the antenna or guy wire and the supply or communication conductor.

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

46. **Common use** means simultaneous use by two or more utilities of the same kind.

47. **Climbing space** means the vertical space reserved along the side of a pole structure to permit ready access for linemen to equipment and conductors located on the pole structure.

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

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

50. **Apparent sag of a span** means the maximum 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.

51. **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.

52. **Urban districts** means thickly settled areas (whether in cities or suburbs) or where congested traffic often occurs. A highway, even though in the country, on which the traffic is often very heavy, is considered as urban.

53. **Rural districts** means all places not urban, usually in the country, but in some cases within city limits.

54. **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.

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

56. **Conduit** means (in overhead or interior work) a tube or duct especially constructed for the purpose of inclosing electrical conductors.

57. **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, 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.

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

59. **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.

60. **Tags** means "men at work" tags of distinctive appearance, indicating that the equipment or lines so marked are being worked on.

61. **Wire gauges**: The American Wire Gauge (A. W. G.), otherwise known as Brown & Sharpe (B. & S.), is the standard gauge for copper, aluminum, and other conductors, excepting steel, for which the Steel Wire Gauge (Stl. W. G.) is used throughout these rules.

SEC. 9. RULES COVERING METHODS OF PROTECTIVE GROUNDING OF CIRCUITS, EQUIPMENT, AND LIGHTNING ARRESTERS FOR STATIONS, LINES, AND UTILIZATION EQUIPMENT

CONTENTS

90. Scope of the Rules.

The following rules apply to the grounding of all lightning arresters, except those on communication circuits, and of all circuits, equipment, or wire runways when the grounding is intended to be a permanent and effective protective measure.

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

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

Other methods of construction and installation than those specified in the rules may be used as experiments to obtain information if done where supervision can be given by the proper administrative authority.

91. Application of the Rules.

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

(b) **Application.**—The intent of the rules will be realized (1) by applying the rules in full to all new installations, reconstructions, and extensions, except where any rule is shown to be impracticable for special reasons or where the advantage of uniformity with existing construction is greater than the advantage of construction in compliance with the rules, providing the existing construction is reasonably safe; (2) by placing grounds on existing installations or bringing present grounds into compliance with the rules, except where the expense involved is not justifiable.

The time allowed for bringing existing installations into compliance with the rules will be determined by the proper administrative authority.

(c) **Temporary installations.**—It will sometimes be necessary to modify or waive certain of the rules in case of temporary installations or installations which are shortly to be dismantled or reconstructed.

(d) **Emergency.**—In cases of emergency or pending decision of the administrator the person responsible for the installation may decide as to modification or waiver of any rule, subject to review by proper authority.

92. Point of Attachment of Grounding Conductor.

(a) **Direct-current distribution systems.**—In three-wire direct-current systems the ground connections shall be made on the neutral at one or more supply stations.

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

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

(b) **Alternating-current distribution systems.**—In alternating-current 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 rule 94) or by the use of a system ground wire to which are connected the grounded conductors of many secondary mains and which is itself effectually grounded at intervals that will fulfill, for any secondary utilizing the system ground wire, the resistance and current-carrying requirements of rule 96.

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.

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

In single-phase, three-wire systems the ground shall be on the neutral conductor. In single-phase two-wire systems the ground may be made on either conductor. In two-wire single-phase and in two or three phase systems the ground shall be made at that point of the system which brings about the lowest voltage from ground of unguarded current-carrying parts of connected devices. Where one phase of a two or three phase system is used for lighting, that phase should be grounded and at the neutral conductor, if one is used.

In the absence of direct grounds 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 requirements of rule 96 (*a*).

(c) **Current in grounding conductor.**—Grounds shall be so arranged that under normal conditions of service there will be no objectionable flow of current over the grounding conductor.

Where the objectionable flow of current over a grounding conductor is due to the use of multiple grounds, one or more of such grounds shall be abandoned or the location changed.

(d) **Equipment and wire runways.**—For conduit, armored cable, metal raceways, generators, motors, transformers, and other equipment, the point at which the grounding conductor is attached shall, if practicable, be readily accessible.

No separate grounding conductor shall be required for noncurrent-carrying parts of equipment if grounded through the conduit, cable sheath, or metal raceway system of the building by means of standard lock nuts and bushings or by a separate bond between the equipment and the conduit, armored cable, or metal raceway system.

For conduit, armored cable, or metal raceways the ground connection shall be as near as practicable to the point where the conductors in the conduit system concerned receive their supply.

(e) **Service conduit.** — When the service conduit is grounded, its grounding wire shall be run directly from it to the ground connection. The interior conduit, armored cable, or metal raceways, if well bonded to the service conduit, grounded as provided in this rule, needs no additional ground connection.

93. Grounding Conductor.

(a) **Material and continuity.**—In all cases the grounding conductor shall be of copper or of other metal which will not corrode excessively under the existing conditions 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 requirements of rule 96.

In no case shall a fuse or automatic circuit-breaker be inserted in the grounding 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; no switch shall be so inserted except in plain sight, provided with distinctive marking and effectively isolated from unqualified persons. (See also rule 92 (*b*), par. 2.)

For lightning arresters and ground detectors the grounding conductor shall be as short and straight as practicable and free from sharp bends.

(b) **Size and capacity.**—The conductor or conductors for grounding circuits shall have a combined current 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 grounding conductor for electrical circuits shall have current capacity less than that of a No. 8 (0.128 inch) copper wire.

The grounding conductor for a direct-current system shall have a current capacity not smaller than the largest feeder of the same system leaving the station.

The grounding conductor for alternating-current systems shall have a current capacity not less than one-fifth that of the conductor to which it is attached, except that it need not be larger than No. 0 (0.325 inch) copper.

For lightning arresters the grounding conductor or conductors shall have a current 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 grounding conductor shall have less conductance than No. 6 (0.162 inch) copper wire.

For noncurrent-carrying parts of electrical equipment the conductance of a grounding conductor shall be not less than that provided by a copper wire of the size indicated in the following table. When there is no fuse or automatic circuit-breaker protecting the equipment, the size of the grounding conductor will be determined by the design and operating conditions of the circuit.

Rating of fuse or circuit-breaker which protects equipment or conductors	Size of grounding wire		Nominal size of grounding pipe
	A. W. G.	*Inch*	*Inch*
Not more than 100 amperes	10	0.102	½
More than 100, but not more than 200 amperes	6	.162	½
More than 200, but not more than 500 amperes	4	.204	¾
More than 500 amperes	2	.258	1

In portable cord to portable equipment protected by fuses not greater than 15 amperes capacity, a No. 18 (0.040 inch) grounding wire may be used.

Grounding wires for conduit, armored-cable, or metal-raceway systems shall have a conductance at least equivalent to No. 10 (0.102 inch) copper where largest wire contained is not larger than No. 0 (0.325 inch), and need not be larger than No. 4 (0.204 inch) where the largest wire contained is larger than No. 0; and for service conduit the grounding wire shall have a conductance not less than that of No. 8 (0.128 inch) copper wire.

(c) **Mechanical protection and guarding against contact.**—Where exposed to mechanical injury the grounding conductor shall be protected by substantial conduit or other guard. Guards for lightning-arrester grounding conductors shall be of nonmagnetic material unless the grounding conductor is electrically connected to both ends of the guard.

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

Note.—Such a high resistance may exist where artificial grounds are necessarily permitted in lieu of the preferable grounds to buried metallic water-piping systems.

Mechanical protection and insulating guards should extend for a distance of not less than 8 feet above any ground, platform, or floor from which grounding conductors are accessible to the public.

Note.—Insulating mechanical protection is advisable for single arrester grounds, even when the connection is made to a water-piping system, and has therefore a low resistance, since a single connection is liable to be accidentally broken.

Even where ground connections have a resistance not exceeding that specified in rule 96 and no guard is therefore provided (or as an additional protection to persons even where guards are used) artificial grounds may be arranged to minimize the potential gradient along the surface of the earth by use of radial connecting wires underneath the earth surface or by other suitable means.

A grounding conductor for a circuit shall be guarded as required for current-carrying conductors of the circuit.

Exceptions.—(1) A grounding conductor for a circuit having multiple grounds, where such conductor is entirely outside buildings and has strength and current capacity not less than No. 6 (0.162 inch) copper wire.

(2) In stations substantial bare ground busses may be used.

(d) **Underground.**—Wires used for grounding conductors, if laid underground, shall, unless otherwise mechanically protected, be laid slack to prevent their being readily broken and shall have joints carefully painted or otherwise protected against corrosion.

94. Ground Connections.

The ground connection shall be permanent and effective, and be made as indicated below, but always to water-piping systems, if available.

(a) **Piping systems.**—For circuits, equipment, and arresters at supply stations, connections shall be made to all available active metallic underground water-piping systems between which no appreciable difference of potential normally exists, if the pipe is of sufficient capacity, and to one such system if appreciable differences of potential do exist between them. At other places connections shall be made to at least one such system, if available. Gas piping should not be used for grounding circuits.

NOTE.—The protective grounding of electrical circuits and equipment to water-pipe systems in accordance with these rules should always be permitted, since such grounding offers the most effective protection to life and property and is not injurious to the piping systems.

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

(b) **Alternate methods.**—Where underground metallic piping systems are not available, other methods which will secure the desired permanence and conductance may be permitted. 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 connection may be made to the steel frame of a building containing the grounded circuits or equipment, to which frames of machines and other non-current-carrying surfaces should also then be connected. 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 footings.

(c) **Artificial grounds.**—When resort must be had to artificial grounds, their number should be determined by the following requirements:

(1) Not more than one such ground is required for lightning arresters, except where for large current capacity.

(2) At least two grounds are required for low-voltage alternating-current distribution circuits at transformers or elsewhere, except as specified in (3).

(3) Where no part of the circuit or equipment protected can be reached by persons while they are standing on the ground or damp floors, or by persons while touching any metallic piping to which the grounding conductor is not effectively connected, a single artificial ground may be used even if its resistance exceeds that specified in rule 96. In such cases it is desirable to provide guards for the grounding conductor in accordance with rule 93 (*c*) wherever it is otherwise accessible, or to provide insulating mats or platforms so located that persons can not readily touch the grounding conductors without standing on such mats or platforms.

(d) **Grounds to railway returns.**—Protective ground connections should not be made to railway negative-return circuits when other effective means of grounding are available, except ground connections from electric railway lightning arresters.

When ground connections are of necessity made to the grounded track return of electric railways, they shall be made in such a manner as not to afford a metallic connection (as indirectly through a grounded neutral with multiple grounds) between the railway return and the other grounded conducting bodies (such as buried piping and cable sheaths).

NOTE.—This rule 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.

Multiple protective ground connections from other circuits to railway returns should be avoided, and where multiple artificial grounds are made on such 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, which flow would reduce their effectiveness, or otherwise cause damage.

95. Method.

(a) **Piping.**—Ground connections to metallic-piping systems shall be made (except as permitted below) on the street side of water meters, which might interrupt the continuity of the underground metallic-pipe systems, but connections may be made immediately inside building walls to secure accessibility for inspection and test. When water meters are located outside buildings or in concrete pits within buildings where piping connections are embedded in concrete flooring, the ground connection may be made on the building side of the meters.

Ground connections for equipment, conduit, armored cable or metal raceways, and the like, or as a multiple ground for alternating-current secondaries, may be made to the water-piping system at a point near the part to be protected, provided there are no insulating joints or fittings in the pipe to prevent a good ground. In such cases care shall be taken to electrically connect all parts of the piping system liable to create a hazard (if they become alive) and the pipe system shall be shunted where necessary around meters, etc., in order to keep the connection with the underground piping system continuous.

Gas-piping systems within buildings should not be used for purposes of this rule, except that gas piping need not be insulated from otherwise well-grounded electrical fixtures, and where the making of another ground connection for a fixture would involve a long run and the fixture is, therefore, of course, not within reach of plumbing or plumbing fixtures, the gas piping may for small fixtures be utilized as the sole ground connection. Where gas piping is so used it must be bonded to the water-piping system at the point of entrance of water piping. (See rules 93 (*a*) and 94 (*a*).)

(b) **Ground clamps.**—The ground connection to metallic-piping systems shall 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.

The grounding conductor shall be attached to the clamp or to the plug by means of solder or by an approved solderless connector. The point of connection shall be as readily accessible as possible, and the position should be recorded.

NOTE.—With bell-and-spigot-joint pipe it may be necessary to connect to several lengths where circuits or equipment of large current capacity are being grounded.

(c) **Contact surfaces.**—If conduit, couplings, or fittings having protective coating of nonconducting material, such as enamel, are used, such coating shall be thoroughly removed from threads of both couplings and conduit and such surfaces of fittings where the conduit or ground clamp is secured, in order to obtain the requisite good connection. Grounded pipes shall be free from rust, scale, etc., at the place of attachment of ground clamp.

The armor of conduits, cables, metal raceways, and gas pipes shall be securely fastened in outlet boxes, junction boxes, and cabinets, so as to secure good electrical connection.

In ice houses, packing plants, etc., where a great deal of moisture is present and where conduits are attached to metal cabinets, cut-out, pull or junction boxes, compensators, etc., by means of standard lock nuts and bushings, these conduits should be bonded together with approved ground clamps.

(d) **Artificial grounds.** — Artificial grounds should be located where practicable below permanent moisture level or, failing in this, at least 6 feet deep. Each ground should present not less than 2 square feet of surface to exterior soil. Areas where ground water level is close to the surface should be used when available.

Where facilities are not available for determining the resistance of the ground connection (see rule 96), the exposed surface should be not less than 4 square feet.

Where copper ground plates are used, they should be at least 0.06 inch thick. When driven pipes are used, they should be of galvanized iron and not smaller than three-fourths inch internal diameter, and when cast-iron plates are used they should be at least 0.25 inch thick.

96. Ground Resistance.

(a) **Limits.**—The combined resistances of the grounding wire and the connection with the ground shall not exceed 3 ohms for water-pipe connections nor 25 ohms for artificial (buried or driven) grounds. Where it is impracticable to obtain with one ground artificial-ground resistance as low as 25 ohms, this requirement shall be waived, and two artificial grounds, at least 6 feet apart and with combined area of not less than 4 square feet, shall be provided.

(b) **Checking.**—The resistance of station grounds should be checked when made.

NOTE.—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 not less than 20 feet distant.

If the station ground is to water piping, the check may be made with current flowing through the water piping and some independent piping system or artificial ground not less than 20 feet distant.

The auxiliary rod or pipe should be at least 10 feet from any artificial ground or piping systems through which the measured current is made to flow.

All ground connections shall be inspected periodically.

Ground connections on distribution circuits should, when installed, be tested for resistance unless multiple grounding to water-piping systems is used.

97. Separate Grounding Conductors and Grounds.

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

(1) Lightning arresters.

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

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

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

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

(6) Lightning rods.

(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 1. RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL SUPPLY STATIONS AND EQUIPMENT

CONTENTS

SEC. 10. PROTECTIVE ARRANGEMENTS OF STATIONS AND SUBSTATIONS

100. Scope of the Rules.

The following rules apply to the electrical supply equipment of indoor and outdoor stations and substations. Provided the equipment is in separate rooms or inclosures, under control of properly qualified persons and accessible only to such persons, they also apply to similar equipment, including generators, motors, storage batteries, transformers, lightning arresters, etc., when installed in factories, mercantile establishments, vehicles, or elsewhere.

101. Application of the Rules and Exemptions.

(a) **Application and waiving of rules.**—The rules are intended to apply to all installations, except as modified or waived by the proper administrative authority or its authorized agents. They are intended to be so modified or waived in particular cases wherever any rules are shown for any reason to be impracticable such as by involving expense not justified by the protection secured; provided equivalent or safer construction is secured in other ways, including special working methods.

Other methods of construction and installation than those specified in the rules may also be made as experiments to obtain information, if done where supervision can be given by the proper adminstrative authority.

(b) **Intent of rules.**—The intent of these rules which constitute a minimum standard will be realized—

(1) by applying the rules in full to all new installations, reconstructions, and extensions;

(2) by altering existing installations as needed in a manner approved by administrative authority.

The time allowed for bringing existing installations into compliance with the rules will be determined by the administrative authority.

(c) **Waiver for temporary installation.**—It will sometimes be necessary to modify or waive certain of the rules in cases of temporary installations or installations which are shortly to be dismantled or reconstructed.

(d) **Waiver in emergencies.**—In cases of emergency or pending decision of the administrator, the person responsible for the installation may decide as to modifications or waiver of any rule, subject to review by proper authority.

102. General Requirements

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

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

(1) *Fireproof construction.*—They shall be, as far as practicable, noncombustible

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

(3) *Hazardous conditions.*—They shall be free from combustible dust or flyings, inflammable gas, or acid fumes in

dangerous quantities. (For battery rooms, see section 13; for auxiliary equipment in hazardous locations, see rule 117.)

(4) *Ventilation.*—They should be well ventilated.

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

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

103. Illumination.

(a) **Under normal conditions.**—Rooms and spaces where electrical apparatus or machinery is located shall have means for artificial illumination in accordance with Table 1. The means of illumination shall be maintained ready for use at all times.

NOTE.—It is not intended that this rule should require permanent lighting in switch cells and similar small spaces occupied by electrical apparatus where permanent lighting is impracticable. The Code of Lighting Factories, Mills, and Other Work Places includes general standards of illumination required from the point of view of safety.

Table 1.—Illumination Intensities

		Minimum	Modern practice
		Foot-candles	*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	1	2 to 4
5	Stairways and passageways where there is moving machinery, exposed live parts, hot pipes, etc. (measured at floor level)	1	2 to 4
6	Any traversed space (measured at floor level)	¼	1 to 2

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

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(b) **Emergency source.**—A separate emergency source of illumination, from an independent generator, storage battery, gas main, lanterns (the latter two should never be used in battery rooms), or other suitable source, shall be provided in every station where an attendant is located.

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

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

(d) **Attachment plugs.**—Portable conductors shall be attached to fixed wiring only through separable attachment plugs which will disconnect all poles by one operation. (See sec. 37 of the code, for portables and pendants.)

104. Floors, Floor Openings, Passageways, Stairs.

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

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

(b) **Passageways.**—Passageways (including stairways) and working spaces shall be unobstructed, and (except such as are used solely for infrequent inspection, construction, and repair) shall, where possible, provide at least 6.5 feet headroom. (See rule 114 for working space.)

(c) **Railings.**—All floor openings over 18 inches deep and raised platforms over 4 feet high shall be provided with suitable railings.

Except for loading platforms, such rails are recommended where height exceeds 18 inches, especially where they are adjacent to live or moving parts or the working space on the platform is restricted.

(d) **Stair guards.**—All stairways consisting of four or more risers shall be provided with handrails.

For very long and steep stairs occasional landings or turns are recommended.

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

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

(f) **Floor toe boards.**—All floor openings over 6 feet deep, and the edges of all raised platforms over 6 feet high, shall, where possible, be provided with suitable toe boards.

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

105. Exits.

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

(b) **Double exits.**—If the plan of the room or space and the character and arrangement of equipment are such that an accident would be liable to close or make inaccessible a single exit, as in the case of long narrow rooms, platforms, passageways, spaces behind switchboards, or wire and pipe tunnels, a second exit shall, if practicable, be provided.

106. Fire-Fighting Appliances.

(a) **Fire extinguishers.**—Each room or space where an operator is in attendance shall be provided with adequate approved fire-extinguishing appliances conveniently located and conspicuously marked. Any such appliances which have not been approved by Underwriters' Laboratories for use on live parts should be plainly and conspicuously marked with a warning to that effect.

(b) **Temperature conditions.**—Fire extinguishers shall not be installed in locations subject to conditions of high or low temperature which will reduce their effectiveness.

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

107. Oil-Filled Apparatus.

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

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

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

When located outdoors they should be adequately isolated.

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

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

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

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

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

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

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

SEC. 11. PROTECTIVE ARRANGEMENTS OF EQUIPMENT

110. General Requirement.

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

111. Inspections.

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

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

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

(d) **New equipment.**—New equipment should be thoroughly inspected before being put in service.

112. Guarding Shaft Ends, Pulleys, and Belts, and Suddenly Moving Parts.

(a) **Transmission machinery.**—This code is supplemented by the Safety Code for Mechanical Power Transmission Apparatus A. E. S. C. B15, which specifies methods for safeguarding pulleys, belts, and other equipment used in the mechanical transmission of power.

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

113. Protective Grounding.

(a) **Grounding method.**—All grounding which is intended to be a permanent and effective protective measure, such as lightning-arrester grounding, grounding of circuits, equipment, or wire raceways, shall be made in accordance with the methods specified in section 9, Methods of protective grounding.

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

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

It is recommended that all metallic guards (including rails, screens, etc.) about electrical supply equipment should be permanently grounded.

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

NOTE.—Hazardous locations include those where dampness, acid fumes, explosives, inflammable gas, or flyings normally exist.

(c) **Grounding equipment during repairs.**—Electrical equipment or conductors normally operating at more than 750 volts, on or about which work is occasionally done while separated from a source of electrical energy by switches or disconnectors only, shall be provided with some means, such as switches, connectors, or readily accessible ground conductor, for grounding them. (See operating rules 423 and 424 of the code.)

114. Guarding Live Parts.

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

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

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

DEFINITIONS.—The guard zone means the space of minimum clearance from guards to electrical parts where guards may be installed by workmen without definite engineering design. The radius of this zone varies with the voltage as specified in column 4 of Table 2. (See rule 422, C, of the code, for working clearances about live parts.)

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

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

Table 2.—Minimum Clearances from Live Parts

1	2		3		4
Voltage between phases	Minimum vertical clearance of unguarded parts		Minimum horizontal clearance of unguarded parts		Minimum clearance from guards to parts. Radius of guard zone
	Feet	*Inches*	*Feet*	*Inches*	*Inches*
600	7	8	3	2	2
2,300	7	9	3	3	3
6,600	7	10	3	4	4
11,000	9	0	3	6	6
22,000	9	3	3	9	9
33,000	9	6	4	0	12
44,000	9	10	4	4	16
66,000	10	5	4	11	23
88,000	11	0	5	6	30
110,000	11	7	6	1	37
132,000	12	2	6	8	44

NOTE.—Interpolate for intermediate values.

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

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

For the relation of the above clearance tables to the manufacture of electrical apparatus, see discussion of rule 114 (*a*).

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

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

(c) **Types of guards.**

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

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

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

(4) *Shields or inclosures.*—Guards inside of the guard zone or less than 4 inches outside, shall completely inclose the parts from contact up to the heights listed in column 2 of Table 2. They shall not be closer to the live parts than listed in column 4 of Table 2, except when suitable insulating material is used with circuits of less than 7,500 volts. (See

note under Table 2.) If more than 4 inches outside of the guard zone, the guards need not extend more than 7½ feet above the floor. Covers or guards, which must at any time be removed while the parts they guard are alive, should be arranged so that they can not readily be brought in contact with live parts.

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

Exception.—On circuits not exceeding 7,500 volts between phases, when other guarding is impracticable, insulation suitable for the voltage involved may be used back of switchboards or in equivalent sheltered locations. Insulating mats or platforms shall be provided so that an operator can not readily touch the insulating covering without standing on the mats.

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

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

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

Ungrounded frames of existing high-voltage series generators.

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

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

NOTE.—Beveled edges will help in many cases.

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

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

(d) Parts of less than 300 volts to ground.—It is recommended that live parts of more than 150 volts to ground be inclosed or guarded when in exposed locations.

115. Working Space About Electrical Equipment.

(a) Where required.—Adequate and readily accessible working space with secure footing shall be maintained about all electrical parts or equipment which require adjustment or examination when exposed *while in service.*

(b) Width of working space.—The horizontal clearance from the farthest edge of the working space to the nearest live part of more than 300 volts to ground, exposed after removing guards, shall be not less than 3 feet plus the guard zone radius as given in column 4 of Table 2. (When the live parts are on only one side, column 3 of Table 2 gives the minimum permissible value for the total width of the free space.) See also rule 104 (*b*) for headroom.

(c) **Elevated parts.**—Clearance about normally elevated or isolated parts requiring occasional adjustment should be provided so the men need not come within the danger zone (see rule 422, C, of the code), around adjacent energized parts, unless guarded in accordance with rules 114 to 116, inclusive.

116. Equipment for Work on Live Parts.

(a) **7,500 volts or less between phases.**—When it is necessary for men to bring their bodies or any material or tools handled into the danger zone (see rule 422, B, of the code), suitable protective devices, such as rubber gloves, rubber sleeves (if necessary), insulating tools, portable rubber mats or insulating stools, rubber blankets, insulated fuse pullers, testing and grounding devices, switch sticks, etc., should be provided, periodically examined, and kept in safe condition. When the voltage exceeds the limit of 5,000 volts set for standard rubber gloves, special gloves should be furnished if the work is conducted so that their use is necessary.

(b) **More than 7,500 volts.**—Suitable protective devices, such as testing and grounding devices, switch sticks, fuse pullers, special insulated tools, etc., should be provided, periodically inspected, and kept in safe condition. Such devices shall provide an ample margin of safety for the voltage involved and should be constructed so that the workman's body can remain outside of the danger zone. (See rule 422, C, of the code.)

117. Hazardous Locations.

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

This inclosure shall be by one of the following methods:

(1) By placing in separate compartments or rooms.

(2) By using nonabsorptive, noncombustible casings of the solidly inclosed type when inflammable dust or flyings are present.

(3) By using nonabsorptive, noncombustible explosion-proof casings when inflammable gas exists in dangerous quantities.

(b) **Grounding.**—The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded as specified in section 9.

118. Shielding of Equipment from Deteriorating Agencies.

Suitable shields or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads or electrical devices or equipment where susceptible to injury by being installed directly under rotating equipment or in other locations where dripping oil, excessive moisture, steam, vapors, or similar agents exist. (For battery rooms see rule 135.)

119. Identification.

(a) **Equipment in general.**—Electrical supply equipment shall be suitably identified when necessary for safety. The identification may be by position, color, number, name plate, label, design, or other means, but the method of identification chosen shall be uniform throughout any one system. (See rule 164 (*a*) for switches.)

The voltage and intended use shall be shown when important.

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

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

SEC. 12. ROTATING EQUIPMENT

(This includes generators, motors, motor generators, and converters)

120. Speed-control and Stopping Devices.

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

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

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

Controls to be used in emergency for machinery and electrical equipment should be so located as to permit operation with a minimum of danger during such emergency. (See rule 165 for fuses and circuit-breakers.)

(c) **Speed limit for motors.**—Machines of the following types shall be provided with speed-limiting devices unless their inherent characteristics or the load and the mechanical connection thereto are such as to safely limit the speed, or unless the machine is always under the manual control of a qualified operator:

(1) Separately excited direct-current motors.

(2) Series motors.

(3) Motor generators and converters which can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

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

(d) **Low-voltage or under-voltage protection.**—All motors so employed or arranged that an unexpected starting of the motor is a hazard, except those with an emergency use, and where the opening of the circuit may cause a special hazard, such as exciter or condenser-pump motors, shall be equipped with low-voltage protection which will automatically cause and maintain the interruption of the motor circuit when the voltage falls below an operating value.

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

(f) **Protection of control circuits.**—Where speed-limiting or stopping devices are electrically operated, the control circuits by which such devices are actuated shall be in conduit or otherwise suitably protected from mechanical injury, in accordance with rule 151.

121. Guards for Live Parts.

(a) **Guards on rotating equipment.**—Guards complying with rule 114 shall be provided.

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

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

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

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

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

122. Grounding Machine Frames.

(a) **Grounding machine frames.**—All frames of rotating electrical equipment shall be permanently grounded except as permitted below and in rule 113.

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

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

(c) **Auxiliaries.**—Exciters and auxiliary circuits electrically connected to generators or other machines of more than

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750 volts to ground (with frames ungrounded) shall be installed, protected, and identified as machines and circuits of the same voltage as that of the machine for which they are auxiliaries.

123. Terminal Bases and Bushings.

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

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

124. Deteriorating Agencies.

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

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

125. Motors.

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

(b) **Motors in hazardous locations.**—Motors with their auxiliary equipment, at which sparking or arcing or high temperature is liable to occur, when in rooms normally containing explosives, inflammable gas, or inflammable flyings, shall be so installed as to reduce the hazard by inclosure in an adequately ventilated separate compartment, by solidly inclosed or explosion-proof type of equipment, or, when protected against flyings only, by partitioning off a space or by a suitable boxing.

Motors should be protected from dust. Inclosed-type motors are recommended in dusty places, being preferable to boxing.

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

SEC. 13. STORAGE BATTERIES

The following rules (except 133) apply only to storage batteries exceeding 50 kilowatt-hours capacity at the eight-hour rate of discharge.

130. Isolation.

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

131. Ventilation.

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

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

Communication of drafts to other rooms should be prevented.

132. Suitable Supports and Floors.

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

133. Guarding Live Parts in Battery Rooms.

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

(b) **Precaution against parts of more than 150 volts.**—No conductor of more than 150 volts to ground shall be placed in any passageway, unless guarded or isolated by elevation.

(c) **Form of guards.**—Guards shall comply with rule 114.

134. Illumination.

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

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

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

135. Acid-resistive Coverings.

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

SEC. 14. TRANSFORMERS, INDUCTION REGULATORS, RHEOSTATS, GROUND DETECTORS, AND SIMILAR EQUIPMENT

140. Current-transformer Secondary Circuits.

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

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

141. Grounding Low-voltage Circuits of Instrument Transformers.

The low-voltage circuits of all instrument transformers shall be permanently grounded unless the circuits are installed, guarded, and plainly indentified as required for the high-voltage circuits of the transformers, in accordance with rule 150.

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

142. Grounding Transformer Cases.

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

Exception.—Exception is permissible in accordance with rule 113 (*b*), in locations free from inflammable gas, where the entire transformer is isolated or guarded as required for the highest-voltage circuit connected with the transformer, and is plainly and conspicuously identified as of that voltage.

143. Location and Arrangement of Transformers.

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

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

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

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

Where the amount of oil in transformer casings is considerable and the transformers are located in buildings used for other than station purposes, they should be placed in suitable transformer vaults.

(4) In rooms containing other equipment.

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

144. Resistance Devices.

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

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

Rheostats or resistance devices exposed to excessive dust or flyings should preferably be installed in suitable cabinets or equipped with dustproof side and face plates. (For installation in hazardous locations see rule 117.)

145. Ground Detectors.

Every station supplying circuits which are not permanently grounded in accordance with section 9 shall be provided with one or more reliable means of ground detection which can be applied to determine the existence of a ground on any such circuit extending outside the station.

SEC. 15. CONDUCTORS

150. Electrical Protection.

(a) **Fuses required.**—Conductors shall be suitable for the location, use, and voltage. Conductors should be protected against excessive heating by the design of the system or by suitable fuses or automatic circuit-breakers except as provided in rule 165.

Automatic circuit-breakers may be set so as to interrupt the circuits only on excessive short-circuits, if constant attendance is provided and protection is thus also afforded by manual operation.

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

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

151. Precaution Against Mechanical and Thermal Damage.

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

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

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

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

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

(d) **Conductors between generators and outside lines.**—Conductors between generators and outside lines shall be accessible and supported on approved noncombustible, nonabsorptive insulators or placed in approved cable, metal conduit, tile, or other fireproof ducts.

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

152. Isolation.

All conductors of more than 750 volts, and ungrounded bare conductors of more than 300 volts to ground, shall be isolated by elevation or guarded in accordance with rule 114, so that no person can inadvertently come in contact with them; provided that busses and bus structures and line connections thereto may be installed in accordance with rule 115, in suitable locations specially arranged for such purposes.

153. Guarding Conductors.

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

(b) **Form of guards.**—Guards shall comply with rule 114.

154. Guarding in Hazardous Locations.

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

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

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

155. 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.

156. Wiring for Illumination.

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

SEC. 16. FUSES, CIRCUIT-BREAKERS, SWITCHES, AND CONTROLLERS

160. Accessible and Indicating.

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

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

161. Oil Switches.

Oil circuit-breakers and oil switches shall, wherever practicable, be isolated from other types of switches and other electrical apparatus to conform to rule 107 (*a*).

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

NOTE.—Remote control may be of mechanical, electrical, or other type. It is not intended to prohibit the use of switches and circuit breakers operated manually by means of levers or poles from a remote position. (See note in rule 107 (*a*) for conditions usually applying to electrical systems.)

162. Where Switches Are Required.

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

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

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

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

(4) Switches are not required in grounded conductors.

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

163. Switches or Other Grounding Devices.

It is recommended that switches or other suitable means be provided, where practicable, to facilitate short-circuiting and grounding equipment or lines for which the operating rules (see rules 423 and 424 of the code) require grounding to protect workmen. (See rule 113 (*c*).)

164. Capacity of Switches and Disconnectors.

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

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

It is recommended that disconnectors be marked with warning against opening when carrying load. Where a group of disconnectors is contained in one room or compartment a single conspicuous sign may be sufficient.

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

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

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

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

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

An air-break switch or air-break disconnector shall be inserted in each conductor between electrical supply equipment or lines and sources of energy of more than 7,500 volts, if the equipment or lines may have to be worked on without protective grounding while the sources may be alive. (For lightning arresters see rule 181.)

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

165. Where Fuses or Automatic Circuit-Breakers Are Required.

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

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

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

(2) Grounded conductors.

(3) Circuits for field excitation.

(4) Leads of alternating-current generators.

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

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

(7) Leads of series transformers.

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

166. Disconnection of Fuses Before Handling.

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

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

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

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

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

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

167. Arcing or Suddenly Moving Parts.

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

(b) **Protection against moving parts.**—Handles or levers of circuit-breakers and similar parts which may move suddenly, in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

168. Grounding Noncurrent-carrying Metal Parts.

Exposed noncurrent-carrying metal parts of switch and fuse cases, levers, and other similar parts to which leakage is liable to occur from live parts, and thereby create a hazard, shall be permanently grounded in accordance with rule 113.

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

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

Switches, fuses, and automatic circuit-breakers shall be isolated or guarded in accordance with rules 114 and 115.

SEC. 17. SWITCHBOARDS

170. Location and Accessibility.

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

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

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

(c) **Accessibility.**—Switchboards shall be accessible to authorized operators from both sides when the connections are on the back (see rule 115 for working space), but may be placed against a wall when operating at not more than 750 volts with the wiring entirely on the face.

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

171. Material and Illumination.

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

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

172. Necessary Equipment.

Switchboards which control generating equipment or outgoing supply circuits shall (except in substations without regular attendance) be equipped with such instruments as are necessary to show operating conditions. (See rule 145 for ground detectors.)

173. Arrangement and Identification.

Connections, wiring, and equipment of switchboards and panelboards shall be arranged in an orderly manner, and all switches, fuses, and circuit breakers shall be plainly marked, labeled, or arranged so as to afford ready means for identifying circuits or equipment supplied through them, in accordance with rule 119.

174. Spacings and Barriers Against Short-Circuit.

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

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

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

175. Switchboard Grounding.

(a) **Frames.**—Switchboard frames and noncurrent-carrying parts shall be permanently grounded under the conditions and with the exceptions noted in rule 113.

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

(b) **Circuits worked on.**—Where protective grounds are occasionally required on circuits for the protection of workmen, a permanent ground connection shall be provided, and also suitable means for effectively and readily connecting the parts being grounded to the ground connection, in accordance with rule 113 (*c*).

176. Guarding Live Parts on Switchboards.

(a) **Guards.**—Live parts of switchboards shall be guarded in accordance with rule 114.

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

(c) **Exposed parts of more than 7,500 volts.**—No switchboard shall have current-carrying parts of more than 7,500 volts exposed (unguarded) unless these parts are effectively isolated by elevation, except at times when occasionally left exposed by removal of covers or entrance into inclosures, such as switch and instrument-transformer cells or compartments, which are ordinarily unoccupied by persons. For such parts, if exposed while alive for any purpose (including busses and disconnectors in compartments), working space shall be provided complying with the requirements under rule 115.

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177. Instrument Cases.

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

SEC. 18. LIGHTNING ARRESTERS

180. Location.

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

Exception.—This rule need not be complied with in locations where thunderstorms are infrequent at all seasons of the year.

(b) **Indoors.**—Lightning arresters with auxiliaries when installed inside of buildings shall be located well away from all other equipment, passageways, and combustible parts of buildings. When of a type containing oil they should be installed in accordance with rule 107.

181. Provisions for Disconnecting.

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

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

(b) **Working space.**—Such disconnectors, unless remotely controlled and operated, shall have the adjacent working spaces required by rule 115 for disconnectors generally.

182. Connecting Wires.

Ground wires shall be run as directly as possible and be of low impedance and ample current capacity. (See sec. 9 for methods of protective grounding.)

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

183. Grounding Frames and Cases of Lightning Arresters.

All noncurrent-carrying metal parts of arresters shall be grounded, unless effectively isolated by elevation or guarded as required for live parts of the voltage of the circuit to which the arrester is connected, and suitably identified as of that voltage, in accordance with rule 113.

184. Guarding Live and Arcing Parts.

(a) **Protection from contact or arcing.**—All current-carrying parts of arresters on circuits of more than 750 volts, unless effectively isolated by elevation, shall be adequately guarded to protect persons from inadvertent contact with them, or from injury by arcing, in accordance with rule 114.

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

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

PART 2. RULES FOR THE INSTALLATION AND MAINTENANCE OF OVERHEAD AND UNDERGROUND ELECTRICAL SUPPLY AND COMMUNICATION LINES

CONTENTS

SEC. 20. SCOPE, NATURE, AND APPLICATION OF RULES

200. Scope of Rules.

A. Extent of application.—The following rules apply to electrical supply and electrical communication lines in overhead and underground construction whether operated in connection with public utilities, privately or municipally owned, with industrial establishments, or otherwise.

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

C. Conformity with good practice.—Construction should be made according to accepted good practice for the given local conditions in all particulars not specified in the rules.

201. Application of the Rules and Exemptions.

A. Intent, modification.—The rules shall apply to all installations except as modified or waived by the proper administrative authority. They are intended to be so modified or waived whenever they involve expense not justified by the protection secured or for any other reasons are impracticable; or whenever equivalent or safer construction can be more readily provided in other ways.

B. Realization of intent.—The intent of the rules will be realized:

1. By applying the rules in full to all new installations, reconstructions, and extensions, except where for special reasons any rule is shown to be impracticable or where the advantage of uniformity with existing construction is greater than the advantage of construction in conformity with the rules.

2. By placing guards on existing installations or otherwise bringing them into compliance with the rules, except where the expense involved is not justifiable.

NOTE.—The time allowed for bringing existing installations into compliance with the rules as specified in 2 will be determined by the proper administrative authority.

C. Waiver for temporary installations.—It will sometimes be necessary to modify or waive certain rules in cases of temporary installations or installations which are soon to be discarded or reconstructed.

D. Waiver in emergencies.—In case of emergency or pending decision of the administrator, the person responsible for the installation may decide as to modification or waiver of any rule, subject to review by proper authority, but shall first notify all parties directly concerned in advance of construction.

202. Minimum Requirements.

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

NOTE.—Some of these minimum values are exceeded in much existing construction; service requirements frequently call for stronger supports and higher factors of safety than the minimum requirements of these rules.

SEC. 21. GENERAL REQUIREMENTS APPLYING TO OVERHEAD AND UNDERGROUND LINES

210. Design and Construction.

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

211. Installation and Maintenance.

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

212. Accessibility.

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

213. Inspection and Tests of Lines and Equipment.

A. When in service.

1. *Initial compliance with rules.*—Lines and equipment shall comply with these safety rules upon being placed in service.

2. *Inspection.*—Lines and equipment shall be systematically inspected from time to time by the person responsible for the installation.

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

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

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

B. When out of service.

1. *Lines infrequently used.*—Supply lines and equipment infrequently used shall be inspected to see that they are in safe condition for service.

2. *Lines temporarily out of service.*—Lines temporarily out of service shall be maintained in such condition that a hazard will not be created.

3. *Lines permanently abandoned.*—Lines permanently abandoned shall be removed if they might create a hazard.

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

214. Isolation and Guarding.

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

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

As an alternative to isolation or guarding, grounding of certain noncurrent-carrying parts is permitted by rule 215, B, and rule 280, A, 4.

215. Grounding of Circuits and Equipment.

A. Methods.—The methods to be used for permanent grounding for lightning arresters of supply lines, for circuits, for equipment and for wire raceways are given in section 9. The methods to be used for grounding of lightning arresters of communication lines are specified in rule 393.

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

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

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

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

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

NOTE.—Metal conduit above ground which contains extensions from metal-sheathed underground cable is considered to be sufficiently grounded by the cable sheath, provided such sheath is in good contact with the earth or is connected to a good ground. (For method of grounding see section 9.)

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

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

216. Arrangement of Switches.

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

B. Indicating open or closed position.—All switches shall indicate clearly whether they are open or closed.

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

SEC. 22—28. RULES FOR OVERHEAD LINES

SEC. 22. RELATIONS BETWEEN VARIOUS CLASSES OF LINES

220. Relative Levels.

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

NOTE.—This practice facilitates the extension of lines and promotes the safety of the public and workers by permitting the relative levels and required clearances to be readily obtained on jointly or commonly used poles as well as at crossings and conflicts.

B. Relative levels—supply and communication conductors.

1. *Preferred levels.*—Where supply and communication conductors cross each other or are in conflict, or are located on the same poles or towers, the supply conductors shall preferably be carried at the higher level.

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

NOTE.—Supply lines generally use larger conductors than communication lines, so there is less liability of contact between the two if the supply conductors are located in the upper position. This relative location also avoids the necessity of workmen on communication conductors passing through supply conductors and working above them, and avoids the necessity of increasing the grade of construction required for communication conductors.

2. *Minor extensions.*—In localities where the practice of placing conductors of communication circuits for public use above supply conductors has been generally established, minor extensions may be made in either system, keeping the conductors in the same relative position. These extensions should not continue beyond a location at which it

becomes practicable to change to the arrangement standardized by these rules.

3. *Special construction for supply circuits, the voltage of which does not exceed 550 volts, and carrying power not in excess of 1,600 watts.*—Where all circuits are owned or operated by one party, or where cooperative consideration determines that the circumstances warrant and the necessary coordinating methods are employed, supply wires carrying a voltage not exceeding 440 volts, where practicable, or in exceptional cases 550 volts between conductors, with transmitted power not in excess of 1,600 watts, when involved in the joint use of poles with communication circuits, may be installed in accordance with Note *h* (3) of Table 1 in rule 232, A, and Note *a* of Table 11 in rule 238, A, 1, under the following conditions:

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

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

(*c*) That there shall be a vertical clearance of at least 2 feet between the cross arm carrying these supply circuits and the next cross arm above. The other pins on the cross arm carrying the supply circuit may be occupied by communication conductors used in the operation or control of railway or supply apparatus, but not for telegraph or telephone service.

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

C. Relative levels—Supply lines of different voltage classifications (as classified in Table 11).

1. *At crossings or conflicts.*—Where supply conductors of different voltage classifications cross each other or are in conflict, the higher-voltage lines shall preferably be carried at the higher level.

2. *On poles used only by supply conductors.*—Where supply conductors of different voltage classifications are on the same poles, relative levels should be as follows:

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

NOTE.—These relative levels will often avoid the necessity of increasing the grade of construction for cross arms, pins, and conductor fastenings of the lower-voltage conductors.

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

(1) A vertical spacing of not less than 4 feet (or 6 feet where required by Table 11, rule 238, A, 1) is maintained between the nearest line conductors of the respective utilities (this space to be identified if necessary as a division space).

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

221. Avoidance of Conflict.

Two parallel pole lines, either of which carries supply conductors, shall where practicable be so separated from each other that neither conflicts with the other. If this is impracticable, then the conflicting line or lines shall be built of the grade of construction required by section 24 for a conflicting line or the two lines shall be combined in a single pole line.

222. Joint Use of Poles by Supply and Communication Circuits.

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

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

C. Conditions under which joint use is desirable.—In the the case of local or distribution circuits along the same highway or similar right of way, where, under the provisions of section 24 applying to joint use, grade C construction or less would be required, joint use is generally preferable to separate pole lines (except sometimes in rural districts) unless the number of conductors is very large or the character of the circuits makes joint use undesirable.

Where circuits other than those mentioned above are involved, the choice between joint use of poles and separate pole lines shall be determined through cooperative consideration, by the utilities concerned, of all the factors involved, including the character of circuits, the total number and weight of conductors, tree conditions, number and location of branches and service drops, availability of right of way, etc. Where such joint use is mutually agreed upon, it shall be subject to the appropriate grade of construction as specified in section 24. Where such joint use is not employed, separate lines as specified in rule 223 shall be used.

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

223. Separate Pole Lines.

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

SEC. 23. CLEARANCES

230. General.

A. Application.—This section covers all clearances involving poles and wires. Clearances of lamps from pole surfaces, from spaces accessible to the general public, and height above ground are covered in rule 286, E.

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

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

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

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.

231. Horizontal Clearances of Supporting Structures from Other Objects.

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

A. From fire hydrants.—Not less than 3 feet.

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

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

C. From curbs.—Not less than 6 inches measured to the street side of the curb.

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

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

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

Table 1.—Minimum Vertical Clearance of Wires Above Ground or Rails

[All voltages are bet ween wires unless otherwise stated. Supply wires include trolley feeders]

Nature of ground or rails underneath wires	Guys; messengers; communication, span, and lightning protection wires; permanently grounded continuous-metal-sheath cables. All voltages	Open supply line wires, arc wires, and service drops			Trolley contact conductors and associated span or messenger wires [a]	
		0 to 750 volts	750 to 15,000 volts	15,000 to 50,000 volts	0 to 750 volts to ground	Exceeding 750 volts to ground
WHERE WIRES CROSS OVER						
Track rails of railroads handling freight cars on top of which men are permitted [b]	*Feet* [c] 27	*Feet* [c] 27	*Feet* [c] 28	*Feet* 30	*Feet* [d] 22	*Feet* [d] 22
Track rails of railroads not included above [b]	[e] 18	18	20	22	[e] 18	[e] 20
Streets, alleys, or roads in urban or rural districts	[f] 18	18	20	22	[e] 18	[e] 20
Driveways to residence garages	10	10	20	22	[e] 18	[e] 20
Spaces or ways accessible to pedestrians only	[g] 15	[h] 15	15	17	[i] 16	[i] 18
WHERE WIRES RUN ALONG						
Streets or alleys in urban districts	[j k] 18	[j] 18	20	22	[e] 18	[e] 20
Roads in rural districts	[j k l] 15	[j] 15	18	20	[e] 18	[e] 20

See footnotes on page 101

Footnotes for Table 1

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

[b] For wire crossings over railways handling only cars considerably lower than ordinary freight cars, the clearance may be reduced by an amount equal to the difference in height between the highest car handled and the highest ordinary freight car, but the clearance shall not be reduced below that required for street crossings.

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

[d] In communities where 21 feet has been established, this clearance may be continued if carefully maintained. The elevation of the contact conductor should be the same in the crossing and next adjacent spans. (See rule 289 D, 2, for conditions which must be met where uniform height above rail is impracticable.)

[e] In communities where 16 feet has been established for trolley contact conductors 0 to 750 volts or 18 feet for trolley contact conductors exceeding 750 volts, this clearance may be continued if carefully maintained.

[f] Where a guy crosses a street or alley in urban districts and the section of the guy above the street or alley is effectively insulated against the highest voltage to which it is exposed, up to 7,500 volts, the clearance may be reduced to 16 feet at the side of the traveled way.

[g] This clearance may be reduced as follows:

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

[h] This clearance may be reduced as follows:

(1) Supply wires (except trolley contact wires) limited to 300 volts to ground	12
(2) Supply wires (except trolley contact wires) limited to 150 volts to ground and located at entrances to buildings	10
(3) Where supply circuits of 550 volts or less, with transmitted power of 1,600 watts or less are run along fenced (or otherwise guarded) private rights of way in accordance with the provisions specified in rule 220, B, 3	10

[i] Trolley con act conductors for industrial railways when not along or crossing over roadways may be placed at a less height if suitably guarded.

[j] Where a pole line along a road is located relative to fences, ditches, embankments, etc., so that the ground under the line will never be traveled except by pedestrians, this clearance may be reduced as follows:

	Feet
(1) Communication conductors limited to 160 volts to ground and transmitted power of 50 watts	8
(2) Supply conductors	12

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

[l] This clearance may be reduced to 13 feet for communication conductors where no part of the line overhangs any part of the highway which is ordinarily traveled, and where it is unlikely that loaded vehicles will be crossing under the line into the fields.

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

232. Vertical Clearance of Wires Above Ground or Rails.

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

A. Basic clearances.—The clearances in Table 1 apply under the following conditions.

Temperature of 60° F., no wind.
Span lengths 0 to 150 feet.
Voltage 0 to 50,000 volts.
Fixed conductor supports.

For other conditions see rule 232, B.

B. Increased clearances.—Greater clearances than given in Table 1 (rule 232, A) shall be provided under the following conditions. The increases required in 1, 2, and 3 below are cumulative where more than one applies.

1. *Spans exceeding 150 feet.*

Exception.—Trolley contact conductors are exempted from this rule.

(*a*) GENERAL.

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

(*b*) AT RAILROAD CROSSINGS.

Where the clearance of conductors is determined by the presence of railroad or railway tracks in the span, the increase in clearance may be determined by the following:

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

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

(*c*) MAXIMUM INCREASE IN CLEARANCE.

The increase in clearance given by (*a*) or (*b*) above need not exceed the limiting values given in the table below provided conductor sags are such that the maximum tension in the conductor does not exceed the specified percentages of its breaking load:

Percentage of breaking load of conductor	Limiting clearance increase in feet for different loading districts		
	Heavy	Medium	Light
50	2.5	3.0	4.0
60	2.5	4.0	5.0

2. *Voltages exceeding 50,000.*—For these voltages the clearances given in Table 1 (rule 232, A) shall be increased at the rate of 0.5 inch for each 1,000 volts of the excess.

3. *Conductors supported by suspension-type insulators at crossings over track rails.*—The clearance shall be increased

by such an amount that the values specified in Table 1 (rule 232, A) will be maintained in case of a broken conductor in either adjoining span, if the conductor is supported as follows:

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

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

4. *Methods of avoiding this increase of clearance.*—Any of the following construction methods will avoid the necessity for the increase in clearance required by rule 232, B, 3.

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

(*b*) *Semistrain-type insulators* at both supports.

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

C. Supply pole wiring at underground risers.—Supply wires connecting to underground systems shall not be run open closer to the ground than is indicated by Table 2:

Table 2.—Clearance Above Ground for Open Supply Wiring

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

233. Wire Crossing Clearances.

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

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

Temperature of 60° F., no wind.

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

Where the upper conductor or wire has fixed supports.

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

Table 3.—Wire Crossing Clearances

[All voltages are between wires except for trolley contact wires where voltages are to ground]

[The insertion of a given clearance in italics indicates that in general the lines operating at the voltage named above this clearance should not cross over the lines at the voltage to the left of the clearance in italics]

Nature of wires crossed over	Communication wires	Open supply wires 0 to 750 volts and permanently grounded continuous-metal-sheath supply cables of all voltages		Open supply wires and service drops		Guys, messengers, span wires, lightning-protection wires [a]
		Line wires	Service drops	750 to 7,500 volts	7,500 to 50,000 volts	
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Communication, including cables and messengers	[b] 2	[c] 4	2	4	6	[b] 2
Supply cables having permanently grounded continuous metal sheath, all voltages	*4*	2	2	2	4	2
Open supply wires:						
0 to 750 volts	*4*	2	2	2	4	2
750 to 7,500 volts	*4*	*2*	*4*	2	4	4
7,500 to 50,000 volts	*6*	*4*	*6*	*4*	4	4
Trolley contact conductors	[d] 4	[d] [e] 4	[d] 4	6	6	[d] 4
Guys, messengers, span wires, lightning-protection wires, service drops 0 to 750 volts	[b] 2	2	2	4	4	[b] 2

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

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

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

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

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

B. Increased clearances.—Greater clearances than given in Table 3 (rule 233, A) shall be provided under the following conditions. The increases required in 1, 2, and 3 below are cumulative where more than one applies.

1. *Where the sum of the distances from the nearer supporting structure of each span to the point of intersection exceeds 100 feet.*—Under this condition the clearances given in Table 3 (rule 233, A) shall be increased by 0.1 foot for each 10 feet of the excess over 100 feet. This increase need not exceed the limiting values given below when the sag of the upper conductor is such that the maximum stress in that conductor will not exceed the specified percentage of its ultimate stress.

Percentage of ultimate conductor stress	Maximum increase in feet for different loading territories		
	Heavy	Medium	Light
50	2.5	3.0	4.0
60	2.5	4.0	5.0

2. *Voltages exceeding 50,000.*—For these voltages the clearances given in Table 3 (rule 233, A) shall be increased at the rate of 0.5 inch for each 1,000 volts of the excess.

3. *Conductors supported by suspension-type insulators at crossings over communication wires.*—For such conductors the clearance shall be increased by such an amount that the values specified in Table 3 (rule 233, A) will be maintained in case of a broken conductor in either adjacent span, provided such conductor is supported as follows:

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

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

4. *Methods of avoiding this increase of clearance.*—Any of the following construction methods will avoid the necessity for the increase in clearance required by rule 233, B, 3.

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

(*b*) *Semistrain-type insulators* at both supports.

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

234. Clearances of Conductors of One Line from Other Conductors and Structures.

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

1. Four feet.

2. The values required by rule 235, A, 2, (*a*) (1) or (2) for separation between conductors on the same support.

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

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

1. Three feet if practicable.

2. The values required by rule 235, A, 2, (*a*) (1) and (2) for separation between similar conductors on the same support, increased by 1 inch for each 2 feet of the distance from the supporting structure of the second line to the nearest supporting structure of the first line.

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

C. Clearances from buildings.

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

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

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

3. *Open supply conductors attached to buildings.*—Where the permanent attachment of open supply conductors of any class to buildings is necessary for an entrance, such conductors shall meet the following requirements:

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

(*b*) Clearance of wires from building surface shall be not less than those required in Table 9 (rule 235, A, 3, (*a*)) for clearance of conductors from pole surfaces.

4. *Conductors passing by or over buildings.*—

(*a*) MINIMUM CLEARANCES.

Unguarded or accessible supply conductors carrying voltages in excess of 300 volts shall not come closer to any building or its attachments (balconies, platforms, etc.) than listed below.

(1) SPANS: 0 TO 150 FEET.

Table 4.—Clearances of Supply Conductors from Buildings

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

(2) Spans Exceeding 150 Feet.—Where span lengths exceed 150 feet, the increased clearances required by rule 232, B, 1, shall be provided.

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

(*b*) CROSSING ROOFS.

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

(*c*) GUARDING OF SUPPLY CONDUCTORS.

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

(1) Where the clearances set forth in Table 4 (rule 234, C, 4, (*a*), (1)) can not be obtained.

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

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

D. Clearances from bridges.

1. *Clearances of conductors from bridges.*—Supply conductors, not installed in grounded conduit or metal-sheath

cable, which pass under, over, or near a bridge shall have clearances therefrom not less than given in Table 5.

Table 5.—Clearances from Bridges

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

[a] Where over traveled ways on or near bridges the clearances of rule 232 apply.
[b] Bridge seats of steel bridges carried on masonry, brick, or concrete abutments which require frequent access for inspection shall be considered as readily accessible portions.
[c] Conductors should have clearance not less than given in this column, where practicable.
[d] Conductors should have the clearances given in this column increased as much as practicable.

2. *Guarding trolley contact conductors located under bridges.*

(*a*) WHERE GUARDING IS REQUIRED.

Guarding is required where the trolley contact conductor is located so that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

(*b*) NATURE OF GUARDING.

Guarding shall consist of a substantial inverted trough of nonconducting material located above the contact conductor, or of other suitable means of preventing contact between the trolley pole and the bridge structure.

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235. Minimum Line-conductor Clearances and Separations at Supports.

A. Separation between conductors on pole lines.

1. *Application of rule.*

(*a*) MULTI-CONDUCTOR WIRES OR CABLES.

Cables, and duplex, triple, or paired conductors supported on insulators or messengers, whether single or grouped, are for the purposes of this rule considered single conductors even though they may contain individual conductors not of the same phase or polarity.

(*b*) CONDUCTORS SUPPORTED BY MESSENGERS OR SPAN WIRES.

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

(*c*) MEASUREMENT OF CLEARANCES.

The clearances and separations stated may be measured from the center of the supporting insulator instead of from the conductor itself.

2. *Horizontal separations between line conductors.*

(*a*) FIXED SUPPORTS.

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

Exception 1.—The pin spacing at buck-arm construction may be reduced as specified in rule 236, F, to provide climbing space.

Exception 2.—The pin spacing at bridge fixtures may be reduced as specified in rule 235, C.

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

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

Table 6.—Minimum Horizontal Separation at Supports Between Line Conductors of the Same or Different Circuits

Class of circuit	Separation	Notes
Communication conductors	*Inches* 6	Preferable minimum. Does not apply at conductor transposition points.
	3	Permitted where pin spacings less than 6 inches have been in regular use. Does not apply at conductor transposition points.
Railway feeders: 0 to 750 volts, No. 4/0 or larger	6	
0 to 750 volts, smaller than No. 4/0	12	Where 10 to 12 inch separation has already been established by practice, it may be continued, subject to the provisions of rule 235, A, 2, (*a*), (2), for spans having apparent sags not over 3 feet and for voltages not exceeding 7,500.
750 volts to 7,500 volts	12	
Other supply conductors: 0 to 7,500 volts	12	
For all conductors of more than 7,500 volts add for each 1,000 volts in excess of 7,500 volts	0.4	

(2) Separations According To Sags.—The separation at the supports of conductors of the same or different circuits of grades A, B, or C shall in no case be less than the values given by the following formulas, at 60° F. without wind. The requirements of rule 235, A, 2, (*a*), (1) apply if they give a greater separation than this rule.

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

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

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

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

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

Table 7.—Separation in Inches Required for Line Conductors Smaller Than No. 2 A. W. G.

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

Table 8.—Separation in Inches Required for Line Conductors of Size No. 2 A. W. G. or Larger

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

(*b*) SUSPENSION INSULATORS NOT RESTRAINED FROM MOVEMENT.

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

3. *Clearances in any direction from line conductors to supports, and to vertical or lateral conductors, span or guy wires, attached to the same support.*

(*a*) FIXED SUPPORTS.

Clearances shall be not less than given in Table 9.

Table 9.—Minimum Clearance in Any Direction from Line Conductors to Supports, and to Vertical or Lateral Conductors, Span or Guy Wire, Attached to the Same Support

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

[a] If practicable.
[b] Clearance shall not be less than the separation required by Table 6 or rule 235, A, 2, (*a*), (2) between two line conductors of the voltage concerned.
[c] Communication conductors may be attached to supports on the sides or bottoms of cross arms or surfaces of poles if at least 40 inches from any supply line of less than 7,500 volts and at least 60 inches from any supply line of more than 7,500 volts carried on the same pole.
[d] This clearance applies only to supply conductors carried on cross arms below communication conductors on joint poles. Where supply conductors are above communication conductors the clearance shall be at least 3 inches.

(*b*) SUSPENSION INSULATORS NOT RESTRAINED FROM MOVEMENT.

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

4. *Conductor separation—vertical racks.*—Conductors or cables may be carried on vertical racks at one side of the

pole with a vertical separation of at least 4 inches if all the following conditions are met:

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

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

(*c*) Spans shall not average more than 150 feet.

(See Table 9, rule 235, A, 3, for necessary clearances from pole surfaces and rule 236, G, 1, for method of providing climbing space.)

5. *Separation between supply lines of different voltage classifications on the same cross arm.*—Supply lines of any one voltage classification as given in Table 11 (rule 238, A, 1) may be maintained on the same cross arm with supply lines of the next consecutive voltage classification only under the following conditions:

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

(*b*) If in bridge-arm or side-arm construction they are separated by a distance of not less than the climbing space required for the higher voltage concerned and provided for in rule 236.

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

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

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

B. Separation between conductors attached to buildings.—Separation of wires from each other shall not be less than those required in Table 6 (rule 235, A, 2, (*a*), (1)) for separation of conductors from each other at supports.

Exception.—Conductors on vertical racks meeting the requirements of rule 235, A, 4, may have a separation of 4 inches.

C. Separation between conductors attached to bridges.—Supply conductors attached to bridges and supported at frequent intervals may have less separation at supports than required by rule 235, A, 2, (*a*), (1), and (2). The separation shall not be less than the clearance between supply conductors and the surfaces of poles or cross arms required by rule 235, A, 3, (*a*), or less than the following:

Span length:	Separation (inches)
0 to 20 feet	6
20 to 50 feet	9

236. Climbing Space.

A. Location and dimensions.

1. A climbing space having the horizontal dimensions specified in rule 236, E, shall be provided past any conductors, cross arms, or other parts.

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

3. The climbing space shall extend vertically past any conductor or other part between levels above and below the conductor as specified in rule 236, E, F, G, and I, but may otherwise be shifted from any side or corner of the pole to any other side or corner.

B. Portions of supporting structures in climbing space.—Portions of the pole or structure when included in one side or corner of the climbing space at buck or reverse arm construction are not considered to obstruct the climbing space.

C. Cross-arm location relative to climbing space.

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

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

D. Location of supply apparatus relative to climbing space.—Transformers, regulators, lightning arresters, and switches when located below conductors or other attachments shall be mounted outside of the climbing space.

E. Climbing space through conductors on cross arms.

1. *Conductors of same voltage classification on same cross arm.*—Climbing space between conductors shall be of the horizontal dimensions specified in Table 10 (rule 236, E, 3), and shall be provided both along and across the line, and shall be projected vertically not less than 4 feet above and below the limiting conductors. Where communication conductors are above supply conductors of more than 7,500 volts, the climbing space shall be projected vertically at least 6 feet above the highest supply conductor.

Exception.—This rule does not apply if it is the unvarying practice of the employers concerned to prohibit employees from ascending beyond the conductors of the given line, unless the line is killed.

2. *Conductors of different voltage classifications on the same cross arm.*—The climbing space shall be that required by Table 10 (rule 236, E, 3) for the highest voltage of any conductor bounding the climbing space.

3. *Horizontal climbing space dimensions.*

Table 10.—Minimum Horizontal Dimensions of Climbing Space

Character of conductors adjacent to climbing space	Voltage of conductors		Horizontal dimensions of climbing space (inches)			
			On poles used solely by—		On jointly used poles	
	To ground	Between wires	Communication conductors	Supply conductors	Supply conductors above communication conductors	Communication conductors above supply conductors [a]
Communication conductors.	0 to 150		No requirement.		([b])	No requirement.
	Exceeding 150.		24 recommended.		([b])	24 recommended.
Supply conductors.	Less than 300.			24	24	30
	300 to	7,500		30	30	30
		7,500 to 15,000.		36	36	36
		Exceeding 15,000.		More than [c] 36.	More than [c] 36.	More than [c] 36.

[a] This relation of levels is not, in general, desirable and should be avoided where practicable.
[b] The climbing space shall be the same as required for the supply conductors immediately above.
[c] Where practicable. Attention is called to the operating requirements of rule 422.

F. Climbing space on buck-arm construction.—The full width of climbing space shall be maintained on buck-arm construction and shall extend vertically in the same position at least 4 feet (or 6 feet where required by rule 236, E, 1) above and below any limiting conductor.

Method of providing climbing space on buck-arm construction.—With circuits of less than 7,500 volts and span lengths not exceeding 150 feet and sags not exceeding 15 inches for wires of No. 2, and larger sizes, or 30 inches for wires smaller than No. 2, a six-pin cross arm having pin spacing of 14½ inches may be used to provide a 30-inch climbing space on one corner of a junction pole by omitting the pole pins on all arms, and inserting pins midway between the remaining pins so as to give a spacing of 7¼ inches, provided that each conductor on the end of every arm is tied to the same side of its insulator, and that the spacing on the next pole is not less than 14½ inches.

G. Climbing space for longitudinal runs.

1. *General.*—The full width of climbing space shall be provided past longitudinal runs and shall extend vertically in the same position from 4 feet below the run to a point 4 feet above (or 6 feet where required by rule 236, E, 1). The width of climbing space shall be measured from the longitudinal run concerned.

Exception.—If a supply longitudinal run is placed on the side or corner of the pole where climbing space is provided, the width of climbing space shall be measured horizontally from the center of the pole to the nearest supply conductors on cross arms, under the following conditions:

Where the longitudinal run consists of open supply conductors carrying not more than 750 volts or of permanently grounded continuous metal-sheathed supply cable carrying any voltage, and is supported close to the pole as by brackets, racks, or pins close to the pole, and

Where the nearest supply conductors on cross arms are parallel to and on the same side of the pole as the longitudinal run and within 4 feet above or below the run.

2. *Protection of longitudinal runs.*—If a longitudinal run is located between points 2 feet and 6 feet below supply line conductors carried on cross arms, it shall be protected by a suitable guard arm securely fastened to the pole, or by substantial insulating conduit. Such protection shall extend to the following distances from the pole center:

	Inches
Longitudinal runs in general	20
Longitudinal runs of grounded metal-sheath cable uninsulated from metal supports attached to the pole	24

H. Climbing space past vertical conductors.—Vertical runs incased in suitable conduit or other protective covering and securely attached to the surface of the pole or structure are not considered to obstruct the climbing space.

I. Climbing space near ridge-pin conductors.—The climbing space specified in rule 236, E, 3, shall be provided above the top cross arm and past the ridge-pin conductor.

Exception.—Where a single cross arm carrying only two conductors is mounted so that the conductors are 2 feet below a single ridge-pin conductor, the climbing space specified in rule 236, E, 3, shall be carried up to the ridge-pin conductor, but need not be carried past it.

237. Lateral Working Space.

A. Location of working spaces.—Working spaces shall be provided on the climbing face of the pole at each side of the climbing space.

B. Dimensions of working spaces.

1. *Along the cross arm.*—The working space shall extend from the climbing space to the outmost pin position on the cross arm.

2. *Perpendicular to the cross arm.*—The working space shall have the same dimension as the climbing space (see rule 236, E). This dimension shall be measured from the face of the cross arm.

3. *Vertically.*—The working space shall have a height not less than that required by rule 238 for the vertical separation of line conductors carried at different levels on the same support.

C. Location of vertical and lateral conductors relative to working spaces.—The working spaces shall not be obstructed by vertical or lateral conductors. Such conductors shall be located on the opposite side of the pole from the climbing side or on the climbing side of the pole at a distance from the cross arms at least as great as the width of climbing space required for the highest-voltage conductors concerned. Vertical conductors inclosed in suitable conduit may be attached on the climbing side of the pole.

D. Location of buck arms relative to working spaces.—Buck arms may be used under any of the following conditions, provided the climbing space is maintained. Climbing space may be obtained as in rule 236, F.

1. *Standard height of working space.*—Lateral working space of the height required by Table 11 (rule 238, A, 1) may be provided between the buck arms and adjacent line arms to which conductors on the buck arms are not attached.

Method of meeting requirements: This may be accomplished by increasing the spacing between the line cross arm gains.

2. *Reduced height of working space.*—Where no circuits exceeding 7,500 volts between conductors are involved, and the clearances of rules 235, A, 2, (a), (1) and (2) are maintained, buck arms may be placed between line arms having normal spacing, even though such buck arms obstruct the normal working space; provided that a working space of not less than 18 inches in height is maintained either above or below each line arm and each buck arm.

238. Vertical Separation Between Line Conductors, Cables, and Equipment Located at Different Levels on the Same Pole or Structure.

All line conductors, cables, or equipment located at different levels on the same pole or structure shall have the vertical separations set forth below.

A. Vertical separations between horizontal cross arms.—Cross armss upporting line conductors shall be spaced in accordance with Table 11.

1. *Basic separations.*—The separations given in the following table are for cross arms carrying conductors of 0 to 50,000 volts attached to fixed supports:

Table 11.—Vertical Separation of Cross Arms Carrying Conductors

Conductors usually at lower levels	Supply conductors; preferably at higher levels				
	0 to 750 volts and permanently grounded continuous metal-sheath cables of all voltages	750 to 7,500 volts	7,500 to 15,000 volts	15,000 to 50,000 volts	
				Same utility	Different utilities
Communication conductors:					
General	[a] [b] 4	4	6	--------	6
Used in operation of supply lines	2	[c] 2	4	4	6
Supply conductors:					
0 to 750 volts	2	[d] 2	4	4	6
750 volts to 7,500 volts	---------	[d] 2	4	4	6
7,500 volts to 15,000 volts—					
If worked on alive with long-handled tools, and adjacent circuits are neither killed nor covered with shields or protectors	---------	--------	4	4	6
If not worked on alive except when adjacent circuits (either above or below) are killed or covered by shields or protectors, or by the use of long-handled tools not requiring linemen to go between live wires	---------	--------	2	[e] 4	[e] 4
Exceeding 15,000 volts, but not exceeding 50,000 volts	---------	--------	--------	[e] 4	[e] 4

[a] Where supply circuits of 550 volts or less, with transmitted power of 1,600 watts or less, are run below communication circuits in accordance with rule 220, B, 3 the clearance may be reduced to 2 feet.

[b] In localities where the practice has been established of placing on jointly used poles, cross arms carrying supply circuits of less than 300 volts to ground and cross arms carrying communication circuits at a vertical separation less than specified in the table, such existing construction may be continued until the said poles are replaced provided that—

The minimum separation between existing cross arms is not less than 2 feet, and that—

Extensions to the existing construction shall conform to the clearance requirements specified in Table 11.

When communication conductors are all in cable, a supply cross arm carrying only wires of not more than 300 volts to ground may be placed at not less than 2 feet above the point of attachment of the cable to the pole provided that—

The nearest supply wire on such cross arm shall be at least 30 inches horizontally from the center of the pole, and that—

The cable be placed so as not otherwise to obstruct the climbing space.

[c] This shall be increased to 4 feet when the communication conductors are carried above supply conductors unless the communication-line conductor size is that required for grade C supply lines.

[d] Where conductors are operated by different utilities, a minimum vertical spacing of 4 feet is recommended.

[e] These values do not apply to adjacent cross arms carrying phases of the same circuit or circuits.

2. *Increased separations for voltages exceeding 50,000.*—For voltages greater than 50,000, the clearances of Table 11 shall be increased at the rate of 0.4 inch per 1,000 volts of the excess.

B. Vertical separation between line conductors on horizontal cross arms.—Where line conductors are supported on horizontal cross arms spaced as required in rule 238, A, the vertical separation between such conductors shall be not less than the following:

1. *Where conductors on the cross arm are of the same voltage classification.*—Under these conditions, the vertical separation required by Table 11 may be reduced as follows:

Where cross arm separation required by Table 11 is—	Separation between conductors may be reduced to—
2 feet	16 inches
4 feet	40 inches
6 feet	60 inches

2. *Where conductors of different voltage classification are on same cross arm.*—Under these conditions, the vertical separation between conductors on adjacent cross arms shall be that required by Table 11 (rule 233 A, 1) above for the highest voltage classification concerned.

3. *Conductors of different sags on same support.*

(*a*) VARIATION IN CLEARANCE.

Line conductors supported at different levels on the same structure and strung to different sags shall have vertical spacings at the supporting structures so adjusted that the minimum spacing at any point in the span, at 60° F. with no wind, shall not be reduced more than 25 per cent from that required at the supports by rules 235, A, 2 (*a*), (1) and (2) and this rule.

(*b*) READJUSTMENT OF SAGS.

Sags should be readjusted when necessary to accomplish the foregoing, but not reduced sufficiently to conflict with the requirements of rule 261, F, 4. In cases where conductors of different sizes are strung to the same sag for the sake of appearance or to maintain unreduced clearance throughout storms, the chosen sag should be such as will keep the smallest conductor involved in compliance with the sag requirements of rule 261, F, 4.

C. Separation in any direction.—The separation in any direction between conductors of the same or different voltage classification when carried on the same structure, but on cross arms which are not horizontal, shall not be less than the values given in Table 11 (rule 238, A, 1 and 2) for vertical separation.

The separation in any direction shall not in any case be less than the horizontal separation specified in rule 235, A, 2, (*a*), (1) and (2).

D. Vertical separation for line conductors not carried on cross arms.—The vertical separation between conductors not carried on cross arms shall be the same as required in rule 238, A, 1 and 2 for cross arms.

Exception.—Conductors on vertical racks may have a vertical separation of 4 inches under the conditions specified in rule 235, A, 4.

E. Vertical separation between conductors and noncurrent-carrying metal parts of equipment.—For the purpose of measuring these separation metal supports for conductors are considered as noncurrent-carrying metal parts of equipment.

1. *Between supply conductors and communication equipment.*—The vertical separations specified in Table 11 (rule 238, A, 1) as 4 feet may be reduced to 40 inches where the voltage of the supply conductors does not exceed 750, or where supply conductors of any voltage are in permanently grounded continuous-metal-sheath cable.

2. *Between communication conductors and supply equipment.*—The vertical separations specified in Table 11 (rule 238, A, 1) as 4 and 6 feet may be reduced to 40 inches and and 60 inches, respectively.

3. *Between supply and communication equipment.*

(*a*) GENERAL.

The vertical separation specified in Table 11 (rule 238, A, 1) as 4 and 6 feet may be reduced to 40 inches and 60 inches, respectively.

(*b*) SPECIAL SEPARATIONS FOR SPAN WIRES OR BRACKETS.

Span wires or brackets for lamps or trolley contact conductors shall have at least the vertical separation from communication equipment set forth below.

From cross arms carrying communication conductors	2 feet.
From messenger wires carrying communication cables	1 foot.
From terminal box of communication cables, if practicable	1 foot.

Exception.—Where it is not practicable to obtain a clearance of 1 foot from terminal boxes of communication cables, all metal parts of terminals shall have the greatest practicable separation from fixtures or span wires, including all supporting screws and bolts of both attachments.

4. *Supply cross-arm braces considered as equipment.*—Where supply cross-arm braces are less than 1 inch from transformer cases or hangers, the vertical separation from communication equipment shall be measured from the nearest part of this supply equipment, including the cross-arm brace.

F. Vertical separation between communication conductors carried at different levels on railroad crossing poles.—At crossings of communication lines over railroads the vertical clearance between conductors supported on the same pole or structure and at different levels shall in no case be less than 12 inches and preferably shall be 24 inches.

Exception.—Transpositions are excepted.

239. Clearances of Vertical and Lateral Conductors from Other Wires and Surfaces on the Same Support.

Vertical and lateral conductors shall have the clearances and separations required by this rule from other conductors, wires, or surfaces on the same support.

Exception 1.—This rule does not prohibit the placing of supply circuits of the same or next voltage classification in the same iron pipe, if each circuit or set of wires be inclosed in a metal sheath.

Exception 2.—This rule does not prohibit the placing of paired communication conductors in rings attached directly to the pole or to suspension strand.

A. Location of vertical or lateral conductors relative to climbing spaces, working spaces, and pole steps.—Vertical or lateral conductors shall be located so that they do not obstruct climbing spaces or lateral working spaces between line conductors at different levels or interfere with the safe use of existing pole steps.

Exception 1.—This rule does not apply to portions of the pole which workmen do not ascend while the conductors in question are alive.

Exception 2.—This rule does not apply to vertical runs incased in suitable conduit or other protective covering. (See rule 236, H.)

B. Conductors not in conduit.—Conductors not incased in conduit shall have the same clearances from conduits as from other surfaces of structures.

C. Mechanical protection near ground.—Where within 8 feet from the ground, all vertical conductors, cables, and grounding wires shall be protected by a covering which gives suitable mechanical protection. For grounding wires from lightning arresters, the protective covering specified above shall be of wood molding, or other insulating material giving equivalent protection.

Exception 1.—This covering may be omitted for armored cables or cables installed in a grounded metal conduit.

Exception 2.—This covering may be omitted for lead-sheathed cables in rural districts.

Exception 3.—This covering may be omitted for communication circuits on private fenced rights of way in the case of conductors or cables from underground systems.

Exception 4.—This covering may be omitted for grounding wires in rural districts having triple-braid weatherproof covering, or where such grounding wire is one of a number of grounding wires used to provide multiple grounds.

D. Requirements for vertical and lateral supply conductors on supply line poles or within supply space on jointly used poles.

1. *General clearances.*—In general, clearances shall be not less than the values specified in Table 12.

Table 12

Clearance of vertical and lateral conductors	Clearances (in inches) for highest voltage concerned in the clearance	
	0 to 7,500 volts	Exceeding 7,500 volts (add the following for each 1,000 in excess)
From surfaces of supports	3	0.25
From span, guy, or messenger wires	6	.4
From line conductors rigidly supported on fixed supports, such conductors being of—		
Same circuit	3	.25
Different circuits	6	.4
From line conductors not rigidly supported on fixed supports	(a)	(a)

[a] The clearances shall be increased beyond the values given above from line conductors on fixed supports (see rule 235, A, 2, (*b*), and 3, (*b*)).

2. *Special cases.*—The following apply only to portions of a pole which workmen ascend while the conductors in question are alive.

(*a*) Vertical conductors of not more than 7,500 volts shall clear pole centers by not less than 15 inches for a distance of not less than 4 feet above and below any open supply line conductors which are not of more than 7,500 volts when the latter are carried on or within 4 feet from the pole. If the vertical conductors are of more than 7,500 volts, this clearance shall be at least 20 inches. If the supply conductors are of more than 7,500 volts, the clearance from the pole center shall apply for a distance of not less than 6 feet above and below, except as noted in (*b*), (*c*), and (*d*) below.

(*b*) Vertical and lateral supply conductors, including grounding wires which are inclosed in insulated conduit or in metal conduit or cable protected by an insulating covering (or wood molding if wire be used having triple-braid weatherproof covering), whenever within 4 feet of open supply lines of less than 7,500 volts or within 6 feet from open supply lines of more than 7,500 volts may have less than the clearances specified in (*a*) above, except as provided in (*c*) and (*d*) below.

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

(*d*) Vertical and lateral conductors of less than 7,500 volts when on poles used only for supply lines may be run on the street side of the pole in multiple-conductor cables having suitable substantial insulating covering, if such cable is held taut on standard insulators supported on pins and brackets and is arranged so that the cable shall be held at a distance of approximately 5 inches from the surface of the pole, or from any pole step.

E. Requirements for vertical and lateral communication conductors on communication line poles or within the communication space on jointly used poles.

1. *Clearances from wires.*—The clearances and separations of vertical and lateral conductors from other conductors (except those in the same ring run) and from guy, span, or messenger wires shall be 3 inches.

2. *Clearances from pole and cross-arm surfaces.*—Vertical and lateral communication conductors may be attached directly to the pole or cross arm by means of rings, knobs, or brackets provided that they are rubber-insulated paired conductors and that in the case of joint poles the clearances from open supply lines required by Table 11 (rule 238, A, 1) are observed.

F. Requirements for vertical supply conductors passing through communication space on jointly used poles.—Vertical supply conductors, including grounding wires, which pass through communication line space on jointly poles shall be installed as follows:

1. *Metal-sheathed supply cables.*—Metal-sheathed supply cables shall be covered as follows:

(*a*) EXTENT OF COVERING.

Covering shall extend from the lowest points of such cables up to the following distances above the highest communication conductors.

Kind of supply cable	Supply voltage	Distance
		Inches
Metal-sheathed	0 to 7,500	[a] 40
	Over 7,500	60
Permanently grounded continuous-metal-sheathed	All voltages	40

[a] This distance may be reduced to 24 inches for supply cables less than 300 volts to ground where a vertical joint-use separation of 2 feet exists or is permissable. (See footnote *b* to Table 11 for conditions under which this separation is permitted.)

(*b*) NATURE OF COVERING.

The covering shall consist of wood molding or other suitable insulating material at points higher than 8 feet above the ground.

Exception 1.—Iron pipe may be used without insulating covering at points more than 6 feet below the lowest communication wire or railway feeder or attachment.

Exception 2.—Iron pipe may be used throughout if covered with wood molding or other suitable insulating covering from a point 6 feet below the lowest communication wire or railway feeder or attachment to a point 40 inches or 60 inches above the highest communication wire, depending on the supply voltage.

2. *Supply conductors.*—Supply conductors shall be installed in one of the following ways:

(*a*) IN CONDUIT.

Conductors of all voltages may be inclosed in the same way and to the same extent as required in 1 above for metal-sheathed cables.

(*b*) ON PINS AND INSULATORS.

Vertical and lateral conductors of street-lighting circuits and service leads of less than 750 volts may be run on the street side of the pole in multiple-conductor cable having suitable substantial insulating covering if such cable is held taut on standard insulators supported on pins or brackets and arranged so that the cable shall be held at a distance of approximately 5 inches away from the surface of the pole or from any pole steps.

3. *Supply grounding wires.*—Supply grounding wires shall be covered with wood molding or other suitable insulating covering to the extent required for metal-sheathed cables in 1 above, the "voltage" of the grounding wire being taken as the voltage of the supply circuit with which it is associated.

4. *Separation from through bolts.*—Vertical runs of supply conductors shall be separated from the ends of through bolts associated with communication line equipment by one-eighth of the circumference of the pole where practicable, but in no case less than 2 inches.

G. Requirements for vertical communication conductors passing through supply space on jointly used poles.—All vertical runs of communication conductors passing through supply space shall be installed as follows:

1. *Metal-sheathed communication cables.*—Metal-sheathed communication cables shall be covered with wood molding or other suitable insulating covering from a point not more than 8 feet above the ground to the following points above the highest supply conductor.

Nature of supply circuit	Voltage of supply circuit	Distance
		Inches
Permanently grounded continuous-metal-sheathed cable	All voltages	40
Open wire and other cable	0 to 7,500	[a] 40
Open wire and other cable	Exceeding 7,500	60

[a] This distance may be reduced to 24 inches for supply voltages less than 300 volts to ground where a vertical joint-use separation of 2 feet exists or is permissible. (See footnote *b* to Table 11 for conditions under which this separation is permitted.)

2. *Communication conductors.*—Vertical and lateral runs of rubber-insulated paired conductors shall be covered with wood molding or other suitable insulating covering when within 48 or 72 inches from supply conductors of 7,500 volts or less, or more than 7,500 volts, respectively.

3. *Communication grounding wires.*—Grounding wires of communication lines shall be covered with wood molding or other suitable insulating covering to the extent required for metal-sheathed cables in 1 above.

4. *Separation from through bolts.*—Vertical runs of communication conductors shall be separated from the ends of through bolts associated with supply-line equipment by one-eighth of the circumference of the pole where practicable, but in no case less than 2 inches.

SEC. 24. GRADES OF CONSTRUCTION

240. General.

For the purposes of section 26, "Strength requirements," and section 27, "Line insulators," conductors and their supporting structures are classified under the grades specified in this section on the basis of the relative hazard existing.

241. Application of Grades of Construction to Different Situations.

A. Supply cables.—For the purposes of these rules supply cables are divided into two classes as follows:

1. *Specially installed cables.*—In this class are included metal-sheathed supply cables installed in accordance with rule 261, G, 1.

NOTE.—Such cables are sometimes permitted to have a lower grade of construction than open-wire supply conductors of the same voltage.

2. *Other cables.*—In this class are included all other supply cables.

NOTE.—Such cables are required to have the same grade of construction as open-wire supply conductors of the same voltage.

B. Two or more conditions.—In any case where two or more conditions affecting the grade of construction exist, the grade of construction used shall be the highest one required by any of the conditions.

C. Order of grades.—For supply and communication conductors and supporting structures, the relative order of grades is A, B, C, and N, grade A being the highest. Where grades D, E, and N are specified for communication lines, grade D is the highest.

NOTE.—Grades D and E can not be directly compared with the series A, B, and C, but rule 241, D, 3, (*c*) provides for cases where these two conditions are present.

D. At crossings.

1. *Grade of upper line.*—Conductors and supporting structures of a line crossing over another line shall have the grade of construction specified in rules 241, D, 3; 242, and 243.

2. *Grade of lower line.*—Conductors and supporting structures of a line crossing under another line need only have the grades of construction which would be required if the line at the higher level were not there.

3. *Multiple crossings.*

(*a*) WHERE A LINE CROSSES IN ONE SPAN OVER TWO OTHER LINES.

The grade of construction of the uppermost line shall be not less than the highest grade which would be required of either one of the lower lines if it crossed the other lower line.

Example.—If a 2,300-volt line crosses in the same span over a communication line and a direct-current trolley contact conductor of more than 750 volts, the 2,300-volt line is required to comply with grade A construction at the crossing.

This is a double crossing and introduces a greater hazard than where the upper supply line crosses the communication line only.

(*b*) WHERE ONE LINE CROSSES OVER A SPAN IN ANOTHER LINE, WHICH SPAN IS IN TURN INVOLVED IN A SECOND CROSSING.

The grade of construction for the highest line shall be not less than that required for the next lower line.

Exception.—This requirement does not apply when the two upper lines are of such a nature and have such circuit protection that the danger of causing a break in the lower of these two lines by mechanical or electrical contact is eliminated.

(*c*) WHERE COMMUNICATION CONDUCTORS CROSS OVER SUPPLY CONDUCTORS AND RAILROAD TRACKS IN THE SAME SPAN.

The grades of construction shall be in accordance with Table 13.

Table 13

When crossing over—	Communication conductor grades	
	Major lines	Minor lines
Main tracks and supply line of 0 to 750 volts	D	D
Main tracks and supply line exceeding 750 volts	A	A
Minor tracks and supply line of 0 to 750 volts	E	E
Minor tracks and supply line of 750 to 7,500 volts	B	B
Minor tracks and supply line exceeding 7,500 volts	A	B

Recommendation.—It is recommended that the placing of communication conductors above supply conductors at crossings, conflicts, or on jointly used poles be avoided unless the supply conductors are trolley contact conductors and their associated feeders.

E. Conflicts.

1. *How determined.*—Where two lines are adjacent (except at crossing spans) the distance between them and the relative heights above ground of poles and of conductors on each line determine whether conflict exists, and, if so, whether the conflict is a structure conflict (see definition) or a conductor conflict (see definition), or both.

2. *Conductor conflict.*—At conductor conflicts the grade of construction of the conflicting conductor shall be as required by rules 241, D, 3, and 242.

3. *Structure conflict.*—At structure conflicts, the grade of construction of the conflicting structure shall be as required by rule 243.

242. Grades of Construction for Conductors.

The grades of construction required for conductors of all classes in different situations are given in Tables 14 and 15. For the purpose of these tables certain classes of circuits are treated as follows:

A. Status of constant-current circuits.—In determining grades of construction where constant-current circuits are involved with communication circuits and are not in specially installed cable, the constant-current circuits shall be considered on the basis of their current rating. In all other cases constant-current circuits shall be considered on the basis of their nominal full-load voltage.

B. Status of railway feeders and trolley contact conductors.—In determining grades of construction where railway feeders and trolley contact conductors are involved they shall be considered as other supply conductors of the same voltage.

Exception.—Direct-current trolley circuits exceeding 750 volts to ground shall have grade A construction where crossing over, conflicting with, or on joint poles with and above major communication circuits, and grade B where similarly situated with respect to minor communication circuits.

C. Status of communication circuits used exclusively in the operation of supply lines.—In determining grades of construction where communication circuits used exclusively in the operation of supply lines are concerned, they shall be considered as ordinary communication circuits when run as such (see rule 288, C) and as supply circuits when run as such (see rule 288, D).

Exception.—Communication circuits located below supply circuits with which they are used shall not require such supply circuits to meet any rules for grade of construction other than that the sizes of such supply conductors shall not be less than required for grade C (see rule 261, F, 2).

Table 14.—Grades of Construction for Supply Conductors alone, at Crossings, at Conflicts, or on Same Poles with other Conductors

Supply conductors at higher levels[a] / Conductors, tracks, and rights of way at lower levels			Constant-potential supply conductors other than D.C. railway feeders													Constant-current supply conductors						Direct-current railway feeders				Communication conductors used exclusively in the operation of, and run as, supply lines	
			0 to 750 volts[b]		750 to 5000 volts[c]			5000 to 7500 volts[d]				Exceeding 7500 volts[e]				0 to 7.5 amperes		7.5 to 10 amperes		Exceeding 10 amperes		0 to 750 volts		Exceeding 750 volts			
			Urban	Rural	Urban		Rural	Urban		Rural		Urban		Rural													
			Open or Cable	Open or Cable	Open	Cable	Open or Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable	Open	Cable
Lines on fenced rights of way			N	N	[f]N	N	N	[f]N	N	N	N	[f]N	[f]N	N	N	B,C,or N. See rule 242,A						B, C, or N. See rule 242,B				C or N. See rule 242,C	
Lines not on fenced rights of way			N	N	C	N	N	C	N	N	N	B	C	N	N												
Railroad tracks	Main		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	Minor		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Street-railway tracks having no overhead contact conductor			N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Constant-potential supply conductors	0 to 750 volts[b]	Open	N	N	C	N	N	C	N	N	N	B	C	[g]C	N	B, C, or N See rule 242,A						B, C, or N See rule 242,B				B, C, or N See rule 242,C	
		Cable	N	N	C	N	N	C	N	N	N	B	C	[g]C	N												
	750 to 5000 v.[c]	Open	[h]C	N	C	C	N	C	C	N	N	B	C	N	N												
		Cable	N	N	C	N	N	C	N	N	N	B	C	N	N												
	5000 to 7500 volts[d]	Open	[h]C	N	C	C	N	C	C	N	N	B	C	N	N												
		Cable	N	N	C	N	N	C	N	N	N	B	C	N	N												
	Exceeding 7500 volts[e]	Open	[h]B	[h]C	B	B	N	B	B	N	N	B	C	N	N												
		Cable	[h]C	N	C	N	N	C	N	N	N	B	C	N	N												
Constant-current supply conductors open, or cable			B, C, or N. See rule 242,A													B, C,or N. See rule 242,A						B,C,or N. See rules 242,A,B				B,C,or N. See rules 242,A,C	
Direct-current railway feeders open or cable			B, C, or N See rule 242,B													B,C,or N. See rules 242,A and B						B,C,or N. See rule 242,B				B,C,or N. See rules 242,B,C	
Trolley contact conductors A.C. or D.C.			B, C, or N. See rule 242,B													B,C, or N. See rules 242,A and B.						B,C, or N. See rule 242,B				B,C, or N. See rules 242,B,C	
Communication conductors, open or cable, used exclusively in the operation of supply lines			A,B,C, or N. See rule 242,C													A,B,C, or N. See rules 242A and C						A,B,C, or N. See rules 242,B,C.				B,C, or N. See rule 242,C	
Communication conductors, urban or rural open or cable	Major[i]		N	N	C	C	C	B	C	B	C	A	C	A	C	C	C or N See rule 242A	B	C or N See rule 242A	A	C or N See rule 242A	N	N	A	C	B,C, or N. See rule 242,C	
	Minor[i]		N	N	C	C	C	C	C	C	C	B	C	B	C	C		C		B		N	N	B	C		

[a] The words "open" and "cable" appearing in the column headings have the following meanings as applied to supply conductors: "Cable" means the specially installed cables described in rule 241, A, 1. "Open" means open wire and also supply cables not "specially installed."
[b] Voltages to neutral or ground of 0 to 440 volts.
[c] Voltages to neutral or ground of 440 to 2,900 volts.
[d] Voltages to neutral or ground of 2,900 to 4,400 volts.
[e] Voltages to neutral or ground exceeding 4,400 volts.
[f] Where lines are located so that they can fall outside the fenced right of way into urban districts the construction shall comply with the grades specified for lines not on fenced rights of way for corresponding voltage.
[g] Grade N if crossing over or conflicting with supply services.
[h] If the wires are service drops, they may have grade N sizes and sags as set forth in Tables 32 and 33 (rule 263, E).
[i] Where the communication conductors consist of individual paired conductors only, supply conductors in the upper position need only be grade N due to this condition.

Table 15.—Grades of Construction for Communication Conductors Alone, or in Upper Position at Crossings, at Conflicts, or on Joint Poles

Conductors, tracks and rights of way at lower levels \ Communication conductors at higher level[a]			Communication conductors, rural or urban, open or cable, including communication conductors run as such, but used exclusively in the operation of supply lines — Major	Minor
Lines on fenced rights of way			N	N
Lines not on fenced rights of way			N	N
Railroad tracks		Main	D	D
		Minor	E	E
Street-railway tracks having no overhead contact wire			N	N
Constant-potential supply conductors[b]	0 to 750 volts[c]	Open or cable	N	N
	750 to 5000 v.[d]	Open or cable	C	C
	5000 to 7500 v.[e]	Open	B	[g]C
		Cable	C	C
	Exceeding 7500 volts[f]	Open	A	B
		Cable	C	C
Constant current supply conductors[b]	0 to 7.5 amp.	Open[i]	C	C
	7.5 to 10 amp.	Open[i]	B	[g]C
	Exceeding 10 amp.	Open[i]	A	B
Direct-current railway feeders[b]	0 to 750 volts	Open or cable	N	N
	Exceeding 750 v.	Open or cable	A	B
Trolley contact conductors[b]	0 to 750 volts	A.C. or D.C.	[h]D	[h]D
	Exceeding 750 volts	A.C.	A,B, or C	See rule 242,B
		D.C.	A	B
Communication conductors, open or cable used exclusively in the operation of Supply lines			B, C, or N See rule 242,C	
Communication conductors, open or cable, urban or rural, major or minor			N	N

[a] It is recommended that the placing of communication conductors above supply conductors at crossings, conflicts, or jointly used poles be avoided, unless the supply conductors are trolley contact conductors and their associated feeders.

[b] The words "open" and "cable" appearing in the headings have the following meaning as applied to supply conductors: "Cable" means the specially installed cables described in rule 241, A, 1. "Open" means open wire and also supply cables not specially installed.

[c] Voltages to neutral or ground of 0 to 440 volts.

[d] Voltages to neutral or ground of 440 to 2,900 volts.

[e] Voltages to neutral or ground of 2,900 to 4,400 volts.

[f] Voltages to neutral or ground exceeding 4,400 volts.

[g] For spans 150 feet or less in length, grade C supply-conductor sizes and sags shall apply instead of grade D as permitted by rule 261, H.

[h] Applies only to line-conductor sizes and sags in spans 0 to 150 feet long with following exceptions: Copper or steel, spans 0-100 feet, use No. 12 wire; steel, spans 125 to 150 feet, use No. 9 wire. For spans exceeding 150 feet, grade C supply-conductor sizes and sags shall be met. For paired conductors, grade C paired-conductor requirements shall be met.

[i] Where constant-current circuits are in specially installed cable, they are considered on the basis of the nominal full-load voltage.

D. Status of fire-alarm conductors.—In determining grades of construction where fire-alarm conductors are concerned, they shall be considered as other communication circuits.

Exception.—Fire-alarm conductors shall always meet grade D where the span length is from 0 to 150 feet, and grade C where the span length exceeds 150 feet.

243. Grades of Supporting Structures.

A. Poles or towers.—The grade of construction shall be that required for the highest grade of conductors supported.

Exception 1.—The grade of construction of joint poles, or poles used only by communication lines, need not be increased merely because of the fact that communication wires carried on such poles cross over trolley contact conductors of 0 to 750 volts.

Exception 2.—Poles carrying grade C or D fire-alarm conductors, where alone, or where concerned only with other communication conductors, need meet only the requirements of grade N.

Exception 3.—Poles carrying supply service loops of 0 to 750 volts shall have at least the grade of construction required for supply line conductors of the same voltage.

Exception 4.—Where communication lines cross over supply conductors and a railroad in the same span and grade A or B is required by rule 241, D, 3, (*c*) for the communication conductors, due to the presence of railroad tracks, the grade of the poles or towers shall be D or E.

Exception 5.—At structure conflicts even though no conductor conflict exists, the grade of construction which would be required by rule 242, if the conductors were in conflict, shall be applied to the pole or tower.

NOTE.—This requirement may result in a higher grade of construction for the pole or tower than for the conductors carried thereon.

Exception 6.—In the case where a structure conflict does not exist, but any conductor is in conductor conflict, the grade of construction of the pole or tower is not required to meet the conductor grade due to the conductor conflict.

B. Cross arms.—The grade of construction shall be that required for the highest grade of conductors carried by the cross arm concerned.

Exception 1.—The grade of construction of cross arms carrying only communication conductors need not be increased merely because of the fact that such conductors cross over trolley contact conductors of 0 to 750 volts.

Exception 2.—Cross arms carrying grade C or D fire-alarm conductors where alone or where concerned with other communication conductors need meet only the requirements for grade N.

Exception 3.—Cross arms carrying supply service loops of 0 to 750 volts shall have at least the grade of construction required for supply line conductors of the same voltage.

Exception 4.—Where communication lines cross over supply conductors and a railroad in the same span and grade A or B is required by rule 241, D, 3, (*c*) for the communication conductors due to the presence of railroad tracks, the grade of the cross arm shall be D or E.

C. Pins, insulators, and conductor fastenings.—The grade of construction shall be that required for the conductor concerned.

Exception 1.—The grade of construction of pins, insulators and conductor fastenings carrying only communication conductors need not be increased merely because of the fact that such conductors cross over trolley contact conductors of 0 to 750 volts.

Exception 2.—In case of grade C or D fire-alarm conductors where alone or where concerned only with other communication conductors, pins, insulators, and conductor fastenings need meet only the requirements for grade N.

Exception 3.—In the case of supply service loops of 0 to 750 volts, pins, insulators, and conductor fastenings shall have at least the same grade of construction as required for supply line conductors of the same voltage.

Exception 4.—Where communication lines cross over supply conductors and a railroad in the same span, and grade A or B is required by rule 241, D, 3, (*c*) for the communication conductors due to the presence of railroad tracks, the grade of pins, insulators, and conductor fastenings shall be D or E.

Exception 5.—In case communication conductors are required to meet grade A, B, or C, the insulators need meet only the requirements for mechanical strength for these grades.

SEC. 25. LOADING FOR GRADES A, B, C, D, AND E

250. Loading Map.

Three degrees of severity are recognized for the loading, due to weather conditions, and are designated, repectively, as heavy, medium, and light loading. The districts in which these loadings apply are determined by weather reports as to wind and ice and by local experience of utilities using overhead lines. It is expected that detailed districting will be carried out by State authorities, but a general districting for the entire United States is given in the map (fig. 1).

Note.—The localities in the different groups are classed according to the relative prevalence of high wind velocity and thickness of ice which accumulates on wires, light loading being, in general, for places where little, if any, ice ever accumulates on wires.

Where high wind velocities are frequent in a given place the loading for that place may be classed as heavy even though ice does not accumulate to any greater extent than at some other place having less severe winds which has been classed as a medium loading district.

Fig. 1.—*District loading map showing territorial division of the United States with respect to loading of overhead lines*

251. Assumed Weather Conditions.

The following weather conditions are assumed to act simultaneously in different loading districts:

	Thickness of ice	Horizontal wind pressure on projected area of cylindrical surface	Temperature
	Inches	*Pounds per square foot*	° *F.*
Heavy loading districts (H)	0.50	8	0
Medium loading districts (M)	.25	8	+15
Light loading districts (L)	None.	12	+30

252. Modification of Loading.

In the absence of any action by the administrative authority fixing the loadings for any given territory, the classification of loadings shown on the map (fig. 1), shall apply unless the party or parties responsible for the line concerned secure approval from the administrative authority for modification based upon local experience or weather records, or both.

253. Conductor Loading.

The loading on conductors shall be assumed as in A, B, or C below, according to the climatic conditions of the locality concerned.

Where cables are concerned, the specified loadings shall be applied to both cable and messenger.

In applying loadings to bare stranded conductors, the coating of ice shall be considered as a hollow cylinder touching the outer strands.

Ice is assumed to weigh 57 pounds per cubic foot.

A. Heavy loading (H).—The resultant loading, due to the weight of the conductor plus the added weight of a layer of ice 0.5 inch in radial thickness, combined with a transverse horizontal wind pressure of 8 pounds per square foot on the projected area of the ice-covered conductor, shall be called heavy loading. The minimum temperature shall be assumed as 0° F.

B. Medium loading (M).—The resultant loading, due to the weight of the conductor plus the added weight of a layer of ice 0.25 inch in radial thickness, combined with a transverse horizontal wind pressure of 8 pounds per square foot on the projected area of the ice-covered conductor, shall be called medium loading. The minimum temperature shall be assumed as +15° F.

C. Light loading (L).—The resultant loading, due to the weight of the conductor without ice, combined with a transverse horizontal wind load of 12 pounds per square foot on the projected area of the conductor, shall be called light loading. The minimum temperature shall be assumed as +30° F.

254. Loads Upon Line Supports.

A. Assumed vertical loading.—The vertical loads upon poles, towers, foundations, cross arms, pins, insulators, and conductor fastenings shall be their own weight plus the superimposed weight which they support, including all wires and cables, ice-coated in heavy and medium loading districts, together with the effect of any difference in elevation of supports. The radial thickness of ice shall be computed only upon wires, cables, and messengers, and shall be taken as the following:

Heavy loading districts (H), 0.50 inch of ice.
Medium loading districts (M), 0.25 inch of ice.
Light loading districts (L), no ice.

Ice is assumed to weigh 57 pounds per cubic foot.

NOTE.—The weight of ice upon supports is ignored for the sake of simplicity. (See Appendix E, Table 81, for vertical loads of conductors.)

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B. Assumed transverse loading.—In computing the stresses in poles, towers, and side guys the loading shall be taken as one of the following according to climatic conditions of the locality concerned.

1. *Heavy loading* (*H*).—A horizontal wind pressure, at right angles to the direction of the line, of 8 pounds per square foot upon the projected area of cylindrical surfaces of all supported conductors and messengers when covered with a layer of ice 0.5 inch in radial thickness and on surfaces of the poles and towers without ice covering shall be called heavy loading. (See 4 and 5 following.)

For supporting structures carrying more than 10 wires, not including cables supported by messengers, where the pin spacing does not exceed 15 inches, the transverse load shall be calculated on two-thirds of the total number of such wires with a minimum of 10 wires.

2. *Medium loading* (*M*).—A horizontal wind pressure, at right angles to the direction of the line, of 8 pounds per square foot upon the projected area of cylindrical surfaces of all supported conductors and messengers when covered with a layer of ice 0.25 inch in radial thickness and on the surfaces of the poles and towers without ice covering shall be called medium loading. (See 4 and 5 following.)

For supporting structures carrying more than 10 wires, not including cables supported by messengers, where the pin spacing does not exceed 15 inches, the transverse load shall be calculated on two-thirds of the total number of such wires with a minimum of 10 wires.

3. *Light loading* (*L*).—A horizontal wind pressure, at right angles to the direction of the line, of 12 pounds per square foot upon the projected area of cylindrical surfaces of all supported conductors and messengers, poles and towers without ice covering shall be called light loading. (See 4 and 5 following.)

4. *Trolley contact conductors.*—When a trolley contact conductor is supported on a commonly used pole it shall be included in the computation of the transverse load on the structure.

5. *Flat surfaces.*—For flat surfaces the assumed unit wind pressure shall be increased by 60 per cent. Where latticed structures are concerned the actual exposed area of one lateral face shall be increased by 50 per cent to allow for the pressure on the opposite face; this total, however, need not exceed the pressure which would occur on a solid structure of the same outside dimensions. The results obtained by more exact calculations may be substituted for the values obtained by this simple rule.

6. *Angles.*—In cases where, due to change in direction of conductors, an unbalanced side pull is imposed on the supporting structure, a transverse load shall be assumed equal to the resultant of all conductor and messenger tensions as determined by the loadings of rule 253.

C. Assumed longitudinal loading.

1. *Change in grade of construction.*—The longitudinal loading upon supporting structures, including poles, towers, cross arms, pins, and conductor fastenings, at ends of sections required to be of grade A or B construction when located in lines of a lower grade of construction, shall be taken as an unbalanced pull in the direction of the higher-grade section equal to the total pull in one direction of all conductors and cables supported thereon, the conductor loading to be that given in rule 253.

Exception.—For such higher-grade sections having no span exceeding 500 feet in length where the total pull in the direction of the higher-grade section exceeds 30,000 pounds, the assumed loading is modified to 30,000 pounds plus one-fourth the excess above 30,000 pounds with a maximum of 50,000 pounds.

2. *Same grade of construction throughout.*—Where lines are built throughout their length, or between dead-ended points of grade A or B construction, respectively, although not so required, the longitudinal loading upon supporting structures (including poles, towers, cross arms, pins, and conductor fastenings) at crossings, at ends of sections of joint use, and at ends of conflicts required to be of grade A or B construction, respectively, shall be taken as an unbalanced pull in the direction of the crossing, conflict, or joint-use section equal to the pull of one-third of the total number of conductors carried (not including overhead ground wires), such one-third of the conductors being selected so as to produce the maximum stress in the supports. If the application of the above results in a fractional part of a conductor, the nearest whole number shall be used.

3. *Jointly used poles at crossings over railroads or communication lines.*—Where a joint line crosses over a railroad or a communication line and grade A or B is required for the crossing span, the tension in the communication conductors of the joint line may be considered as limited to one-half their breaking strength, provided they are smaller than No. 8 Stl. W. G., if of steel, or No. 6 A. W. G., if of copper, regardless of how small the initial sags of the communication conductors at 60° F.

4. *Dead ends.*—The longitudinal loading upon supporting structures shall be taken as an unbalanced pull equal to the tensions of all conductors and messengers under the conditions of loading specified in rule 253.

5. *Communication conductors on unguyed supports at railroad crossings.*—The longitudinal load shall be assumed equal to an unbalanced pull in the direction of the crossing of all conductors supported, the pull of each conductor being taken as one-half its ultimate strength.

D. Average span lengths.

1. *General.*—The calculated transverse loads, upon poles, towers, and cross arms, except as provided in 2 below, shall be based upon the average span length of a section of line that is reasonably uniform as to height, number of wires, grade, and span length. In no case shall the average value taken be less than 75 per cent or more than 125 per cent of the actual average of the two spans adjacent to the structure concerned.

2. *Crossings.*—In the case of crossings over railroads or communication lines (other than minor communication lines) the actual lengths of the two spans adjacent to the two structures concerned shall be used.

E. Simultaneous application of loads.

1. When calculating transverse strength, the assumed transverse and vertical loads shall be taken as acting simultaneously.

2. In calculating longitudinal strength, the assumed longitudinal loads shall be taken without consideration of the vertical or transverse loads.

SEC. 26. STRENGTH REQUIREMENTS

260. Preliminary Assumptions.

In calculation of stresses no allowance shall be made for deformation, deflection, or displacement of any part of the supporting structure, including suspension insulators.

261. Grades A, B, and C Construction.

A. Poles and towers.—The strength requirements for poles and towers may be met by the structures alone or with the aid of guys or braces.

1. *Average strength of three poles.*—A pole (single-base structure) not individually meeting the transverse strength requirements will be permitted when reinforced by a stronger

pole on each side if the average strength of the three poles meets the transverse strength requirements and the weak pole has not less than 75 per cent of the required strength.

An extra pole inserted in a normal span for the purpose of supporting a service loop may be ignored, if desired, in the calculation of the strength of the line.

Exception for crossing poles.—In the case of crossings over railroads or communication lines (other than minor communication lines) the actual strengths of the crossing poles shall be used.

2. *Reinforced-concrete poles.*—Reinforced-concrete poles shall be of such material and dimensions as to withstand for transverse strength the loads assumed in rules 254, A and B, and for longitudinal strength the loads in rule 254, C, without exceeding the following percentages of their ultimate strength. (Where guys are used, see rule 261, C.)

	Percentage of ultimate strength for different grades		
	Grade A	Grade B	Grade C
For transverse strength (when installed)	33⅓	50	75
For longitudinal strength (at all times):			
In general	100	100	----------
At dead ends	33⅓	50	75

3. *Steel supporting structures.*—Steel supports, steel towers, and metal poles shall be designed and constructed so as to meet the following requirements:

(*a*) TRANSVERSE STRENGTH.

Under the transverse and vertical loads assumed in rule 254, A and B, the calculated stresses in steel members shall not exceed the allowable stresses for transverse strength given in (*d*) below.

(*b*) LONGITUDINAL STRENGTH.

Grades A and B.—Under the longitudinal loads assumed in rule 254, C, the calculated steel members shall not exceed the allowable stresses for longitudinal strength given in (*d*) below.

Grade C.—No longitudinal-strength requirements except at dead ends.

(*c*) MINIMUM STRENGTH.

Steel towers shall have strength sufficient to withstand a transverse load on the towers without conductors due to three times the specified transverse wind pressure without exceeding the allowable stresses for longitudinal strength in Table 16.

(*d*) ALLOWABLE UNIT STRESSES; STEEL.

The values in Table 16 for structural steel are for material having an ultimate tensile stress between 55,000 and 65,000 pounds per square inch and yield point not less than 50 per cent of the ultimate stress.

In the case of special steels having higher yield points, purchased under rigid specification and inspection conditions, an allowance above the tabular stresses in proportion to the respective yield points will be permitted.

As the unit stresses in Table 16 are the maximum allowable, sufficient allowance should be made in the design to insure that in the completed structure the specified unit stresses will not be exceeded.

Table 16.—Allowable Unit Stresses in Steel for Transverse and Longitudinal Strengths

	Allowable stresses for transverse strength			Allowable stresses for longitudinal strength	
	Grade A	Grade B	Grade C	Grades A and B crossings	Grades A and B except at crossings
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*
Structural steel:					
Tension	20,000	26,000	30,000	30,000	33,000
Compression	20,000 −80 L/R	26,000 −90 L/R	30,000 −100 L/R	30,000 −100 L/R	33,000 −100 L/R
Bolts:					
Shear	20,000	24,000	35,000	35,000	40,000
Bearing	40,000	48,000	70,000	70,000	80,000
Rivets:					
Shear	18,000	22,000	30,000	30,000	33,000
Bearing	36,000	44,000	60,000	60,000	66,000

(*e*) THICKNESS OF STEEL.

Steel poles or towers shall have no less thickness of metal in members than the following:

Table 17.—Thickness of Steel

Kind of member	Thickness of main members of cross arms and legs	Thickness of other members
Galvanized:		
For localities where experience has shown deterioration of galvanized material is rapid	*Inches* ¼	*Inches* $\frac{3}{16}$
For other localities	$\frac{3}{16}$	⅛
Painted	¼	[a]¼

[a] Painted bracing members having L/R not exceeding 125 may be $\frac{3}{16}$ inch in thickness.

(*f*) UNSUPPORTED LENGTH OF COMPRESSION MEMBERS.

The ratio of L, the unsupported length of a compression member, to R, the least radius of gyration of the member, shall not exceed the following (these figures do not apply to the complete structure):

Table 18.—L/R for Compression Members

Kind of compression member	*L/R*
Leg members	150
Other members having figured stresses	200
Secondary members without figured stresses	250

(*g*) SPLICES FOR MAIN LEG MEMBERS.

In splices for main leg members where, under the application of the values in Table 16, rule 261, A, 3 (*d*), four or more bolts or rivets are called for, the number of bolts or rivets shall be increased by 10 per cent with a minimum of one additional bolt or rivet.

(*h*) ADDITIONAL REQUIREMENT FOR ANCHOR TOWERS.

When steel supports or towers are used which are not capable of withstanding approximately as great a force longitudinally as transversely, anchor towers shall be placed at intervals not greater than 10 spans. These anchor towers shall be able to withstand the combined longitudinal tension of all conductors under the loads specified in rule 253 up to 10,000 pounds plus one-half the excess above 10,000 pounds without exceeding their ultimate strength.

(*i*) GENERAL CONSTRUCTION FEATURES.

Steel poles or towers, including parts of footings above ground, shall be constructed so that all parts are accessible for inspection, cleaning, and painting, and so that pockets are not formed in which water can collect.

Recommendation.—Unless sample structures, or similar ones, have been tested to assure the compliance of structures in any line with these requirements, it is recommended that structures be designed to have a computed strength at least 10 per cent greater than that required by these rules.

(*j*) PROTECTIVE COVERING OR TREATMENT.

All iron or steel poles, towers, or supporting structures shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

4. *Wood poles.*—Wood poles shall be of such material and dimensions as to meet the following requirements. Where guys are used, see rule 261, C.

(*a*) TRANSVERSE STRENGTH.

Wood poles shall withstand the transverse and vertical loads assumed in rule 254, A and B, without exceeding at the ground line for unguyed poles, or at the point of guy attachment for guyed poles, the appropriate allowable fiber stresses given in Table 20.

(*b*) LONGITUDINAL STRENGTH.

Grades A and B.—The longitudinal strength of wood poles shall be maintained at all times so that they will withstand the longitudinal loading specified in rule 254, C, without exceeding at the ground line for unguyed poles, or at the point of guy attachment for guyed poles, the appropriate ultimate fiber stress given in Table 19.

Grade C.—No longitudinal-strength requirements except at dead ends.

(*c*) ULTIMATE FIBER STRESS.

Different kinds of wood poles are considered as having the ultimate fiber stresses given in Table 19. These ultimate fiber stresses are given so as to identify different kinds of pole timbers with the ultimate fiber stress appearing at the heads of the columns in Table 20.

Table 19.—Ultimate Fiber Stresses of Wood Poles

Kind of wood	Ultimate fiber stress
	Lbs. per sq. in.
Dense yellow pine (meeting standard of A. S. T. M., see Appendix G)	6,500
Other yellow pine Chestnut Western cedar (western red cedar) Cypress	5,000
Eastern cedar (northern white cedar) Redwood	3,600

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

(*d*) TREATED POLES.

The use of treated poles is not required. However, under certain circumstances Table 20 permits higher allowable stresses for treated poles than for untreated poles. Treated poles are poles meeting the following requirements:

(1) PRESERVATIVES.—The preservative used shall be coal-tar creosote or other preservative equally satisfactory with regard to electrical resistance, retention of the preservative within the timber, and efficiency as a preservative. In the case of poles which are butt-treated only, the electrical resistance of the preservative may be disregarded.

(2) FULL-LENGTH TREATMENT.—Pine and other timber subject to rapid decay above ground shall be treated full length by a pressure process or some other equally effective method.

(3) BUTT TREATMENT.—Cedar, chestnut, and other timber not subject to rapid decay above ground shall be treated by any process which will produce impregnation of most of the sapwood from at least 2 feet below the ground line to at least 1 foot above the ground line. In the case of treatments which require perforation, no method shall be used which results in perforation to the cross section required at replacement.

(*e*) ALLOWABLE FIBER STRESSES.

The allowable fiber stresses to be used in computing the strength of treated and untreated poles to withstand vertical and transverse loads are given in Table 20.

Table 20.—Allowable Fiber Stresses (in Pounds per Square Inch) for Wood Poles Under Vertical and Transverse Loading

	When installed					At replacement		
	Treated poles			Untreated poles		Treated or untreated poles		
	For ultimate fiber stress of—			For ultimate fiber stress of—		For ultimate fiber stress of—		
	6, 500	5, 000	3, 600	5, 000	3, 600	6, 500	5, 000	3, 600
At crossings: Poles in lines of one grade of construction throughout— Grade A	2, 170	1, 670	1, 200	1, 670	1, 200	3, 250	2, 500	1, 800
Grade B	3, 250	2, 500	1, 800	2, 500	1, 800	4, 870	3, 750	2, 700
Grade C	4, 870	3, 750	2, 700	3, 750	2, 700	9, 750	7, 500	5, 400
Poles in isolated sections of higher grade of construction in lines of a lower grade of construction— Grade A	2, 170	1, 670	1, 200	1, 250	900	3, 250	2, 500	1, 800
Grade B	3, 250	2, 500	1, 800	1, 670	1, 200	4, 870	3, 750	2, 700
Grade C	4, 870	3, 750	2, 700	3, 000	2, 160	9, 750	7, 500	5, 400
Elsewhere than at crossings: Grade A	2, 600	2, 000	1, 440	1, 670	1, 200	3, 900	3, 000	2, 160
Grade B	3, 900	3, 000	2, 160	2, 500	1, 800	6, 500	5, 000	3, 600
Grade C	6, 500	5, 000	3, 600	3, 750	2, 700	9, 750	7, 500	5, 400

(*f*) FREEDOM FROM DEFECTS.

Wood poles shall be selected timber free from observable defects that would decrease their strength and durability.

(*g*) MINIMUM POLE SIZES.

Wood poles shall have nominal top diameters not less than the following:

Table 21.—Minimum Top Diameters for Wood Poles

Grade of construction	Minimum top diameters for different loading districts		
	Heavy	Medium	Light
	Inches	*Inches*	*Inches*
A	7	7	6
B	6	6	6
C	6	6	6

(*h*) SPLICED POLES.

Spliced poles shall not be used at crossings, conflicts, or joint-use sections requiring grade A, B, or C construction.

5. *Transverse strength requirements for structures where side guying is required, but can only be installed at a distance.*

Grades A and B.—In the case of structures where, because of very heavy or numerous conductors or relatively long spans, the transverse-strength requirements of this section can not be met except by the use of side guys or special structures and it is physically impracticable to employ side guys, the transverse-strength requirements may be met by side-guying the line at each side of, and as near as practicable to, the crossing or other transversely weak structure, and with a distance between such side-guyed structures of not over 800 feet, provided that:

(*a*) The side-guyed structures for each such section of 800 feet or less shall be constructed to withstand the calculated transverse load, due to wind on the supports and ice-covered conductors, on the entire section between the side-guyed structures.

(*b*) The line between such side-guyed structures shall be substantially in a straight line and the average length of span between the side-guyed structures shall not be in excess of 150 feet.

(c) The entire section between the transversely strong structures shall comply with the highest grade of construction concerned in the given section, except as to the transverse strength of the intermediate poles or towers.

Grade C.—The above provision is not applicable to grade C.

6. *Longitudinal-strength requirements for sections of higher grade in lines of a lower grade of construction.*

(a) METHODS OF PROVIDING LONGITUDINAL STRENGTH.

Grades A and B.—The longitudinal-strength requirements for sections of line of higher grade in lines of a lower grade (see for assumed longitudinal loading rule 254, C, 1) are usually met by placing supporting structures of the required longitudinal strength at either end of the higher-grade section of the line.

Where this is impracticable, the supporting structures of the required longitudinal strength may be located one or more span lengths away from the section of higher grade, within 500 feet on either side and with not more than 800 feet between the longitudinally strong structures, provided such structures and the line between them meet the requirements, as to transverse strength and stringing of conductors, of the highest grade occurring in the section, and provided that the line between the longitudinally strong structures is approximately straight or suitably guyed.

The requirements may also be met by distributing the head guys over two or more structures on either side of the crossing, such structures and the line between them complying with the requirements for the crossing as to transverse strength and as to conductors and their fastenings.

Where it is impracticable to provide the longitudinal strength, the longitudinal loads shall be reduced by increasing the conductor sags. This may require greater conductor separations. (See rule 235, A, 2 (a).)

Grade C.—The above provision is not applicable to grade C.

(*b*) FLEXIBLE SUPPORTS.

Grades A and B.—When supports of the section of higher grade are capable of considerable deflection in the direction of the line, as with wood or concrete poles or some types of metal poles and towers, it may be necessary to increase the normal clearances specified in section 23 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 rule 261, A, 3 (*b*).

When the situation is one involving an isolated crossing of higher grade in a line of lower-grade construction, then the structure shall, when practicable, be head-guyed or otherwise reinforced to prevent reduction in the clearances required in section 23.

Grade C.—The above provision is not applicable to grade C.

7. *Strength at angles and dead ends.*—In cases where, due to change of direction of the line or because of dead ends, the longitudinal tensions in the conductors are not normally balanced, the construction shall be such as to withstand the total combined load without exceeding the working stresses for transverse strength.

Where the section of higher grade is not in line with the line beyond this section, suitable guys shall be placed to withstand the resulting transverse forces.

B. Foundations.

1. *Use of foundations.*

(*a*) WOOD AND REINFORCED-CONCRETE POLES.

No special foundation construction is generally required.

(*b*) STEEL POLES OR TOWERS.

Steel poles or towers should preferably be placed on concrete or other suitable foundations extending above the ground line. If, however, the steel is set in earth, it shall be suitably protected against injurious corrosion at and below the ground line.

2. *Strength of foundations.*

(*a*) STEEL SUPPORTS.

The foundations shall be so designed and constructed as to withstand the stresses due to the loads assumed in rule 254. The calculated stresses in any steel parts shall not exceed the stresses specified in rule 261, A, 3 (*d*).

Since in many localities the soil and climatic conditions are such as to alter the strength of foundations considerably from time to time, there should usually be provided a considerable margin of strength in foundations above that which (by calculation) will just withstand the loads under the assumption of average conditions of climate and soil.

(*b*) WOOD AND CONCRETE POLES.

Foundations for poles shall be of such material and dimensions as to withstand the loads assumed in rule 254, A, B, and C, without exceeding the following percentages of their ultimate strength.

	Percentages of ultimate strength for different grades		
	Grade A	Grade B	Grade C
For transverse loads (when stalled)	50	50	75
For longitudinal loads (at all times):			
In general	100	100	----------
At dead ends	50	50	75

C. Guys.

1. *General.*—The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (sec. 28).

2. *For lines in exposed locations.*

Grades A and B.—In exposed situations, such as open country in rural districts, the transverse strength of wood or reinforced-concrete crossing poles in sections of higher grade in lines of a lower grade of construction shall, where practicable, be obtained by the use of side guys in the following situations:

Where more than ten wires are carried, for all span lengths.

Where more than six wires are carried if the span length exceeds 150 feet.

Grade C.—The above provisions do not apply to grade C.

3. *On steel structures.*—The use of guys to obtain compliance with these requirements is regarded as generally undesirable. When guys are necessarily used, the steel supports or towers, unless capable of considerable deflection, shall be regarded as taking all of the load up to their allowable working load, and the guys shall have sufficient strength to take the remainder of the assumed maximum load. (See rule 261, A, 6, (*b*), for flexible supports.)

4. *On wood or concrete poles.*—When guys are used to meet the strength requirements for wood or concrete poles, they shall be considered as taking the entire load in the direction in which they act, the poles acting as struts only.

5. *Strength of guys.*—Guys, when used, shall be of such material and dimensions as will withstand the transverse load assumed in rule 254, B, and the longitudinal load assumed in rule 254, C, without exceeding the following percentages of their ultimate strength:

	Percentages of ultimate strength for different grades		
	Grade A	Grade B	Grade C
For transverse strength (when installed)	50	50	75
For longitudinal strength (at all times):			
In general	100	100	----------
At dead ends	50	50	75

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D. Cross arms.

1. *Vertical strength.*—Cross arms shall, when installed, withstand the vertical loads specified in rule 254, A, without the stress under these loads exceeding 50 per cent of the assumed ultimate stress of the material.

Exception.—For built-up steel cross arms on steel structures see rule 261, A, 3, (*d*), for allowable working stresses in steel.

2. *Bracing.*—Cross arms shall be securely supported by bracing, if necessary, so as to support safely all other loads to which they may be subjected in use, including linemen working on them. Any cross arm or buck arm except the top one shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

3. *Longitudinal strength.*

(*a*) GENERAL.

Cross arms shall withstand any unbalanced longitudinal loads to which they are exposed, with a limit of unbalanced tension where conductor pulls are normally balanced, of 700 pounds at the outer pin.

(*b*) AT ENDS OF HIGHER-GRADE CONSTRUCTION IN LINE OF LOWER GRADE.

Grades A and B.—Wood cross arms shall be of sufficient strength to withstand at all times, without exceeding their ultimate strengths, an unbalanced pull in the direction of the higher-grade section equal to the tension in all supported conductors under assumed maximum loading as given in rule 254, C, 1. Steel arms shall withstand this load without exceeding the working stresses for longitudinal loads given in rule 261, A, 3, (*d*).

Grade C.—The above provisions do not apply to grade C.

(*c*) AT ENDS OF TRANSVERSELY WEAK SECTIONS.

Grades A and B.—The cross arms connected to the structure at each end of the transversely weak section, such as described in rule 261, A, 5, shall be such as to withstand at all times without exceeding their ultimate strengths under the conditions of loading prescribed in rule 254, C, 1, an unbalanced load equivalent to the combined pull in the direction of the transversely weak section of all the conductors supported.

Grade C.—The above provision does not apply to grade C.

(*d*) METHODS OF MEETING RULES 261, D, 3, (*b*) AND (*c*).

Grades A and B.—Where conductor tensions are limited to a maximum of 2,000 pounds per conductor, double wood cross arms fitted with spacing bolts equipped with spacing nuts and washers, pipe spacers, or similar construction, or with spacing blocks or plates, will be considered as meeting the strength requirements in (*b*) and (*c*) preceding.

Grade C.—The above provisions do not apply to grade C.

4. *Dimensions of cross arms of selected yellow pine or fir.*—The cross-sectional dimensions of selected yellow pine or fir cross arms shall be not less than the values of Table 22.

Table 22.—Cross-Arm Cross Sections

Number of pins	Grades A and B	Grade C	
		Supply	Communication
	Inches	*Inches*	*Inches*
2 or 4	3 by 4	2¾ by 3¾	
6 or 8	3¼ by 4¼	3 by 4	
6			2¾ by 3¾
10			3 by 4

5. *Double cross arms at angles or dead ends.*

Grades A and B.—Where conductors are supported on pin insulators, double cross arms shall be used at unbalanced corners and dead ends in order to permit conductor fastenings at two insulators and so prevent slipping.

Grade C.—The above provision does not apply to grade C.

6. *Location.*—In general, cross arms should be maintained at right angles to the axis of the pole and to the direction of the attached conductors. At crossings, cross arms should be attached to that face of the structure away from the crossing, unless special bracing or double cross arms are used.

E. Pins and conductor fastenings.

1. *Longitudinal strength.*

(*a*) GENERAL.

Pins and ties or other conductor fastenings shall have sufficient strength to withstand an unbalanced tension in the conductor up to a limit of 700 pounds per pin or fastening.

(*b*) AT ENDS OF HIGHER-GRADE CONSTRUCTION IN LINE OF LOWER GRADE.

Grades A and B.—Pins and ties or other conductor fastenings connected to the structure at each end of the higher-grade section shall be of sufficient strength to withstand at all times without exceeding their ultimate strength an unbalanced pull in the direction of the higher-grade section due to the loading specified in rule 254, C, 1.

Grade C.—The above provisions do not apply to grades C.

(*c*) AT ENDS OF TRANSVERSELY WEAK SECTION.

Grades A and B.—Pins and ties or other conductor fastenings connected to the structure at each end of the transversely weak section as described in rule 261, A, 5, shall be such as to withstand at all times without exceeding their ultimate strength under conditions of loading prescribed in rule 254, C, 1, the unbalanced pull in the direction of the transversely weak section of the conductor supported.

Grade C.—The above provisions do not apply to grade C.

(*d*) METHODS OF MEETING RULES 261, E, 1 (*b*) AND (*c*).

Grades A and B.—Where conductor tensions are limited to 2,000 pounds and such conductors are supported on pin insulators, double pins and ties or equivalent fastenings will be considered to meet the requirements (*b*) and (*c*) preceding.

Grade C.—The above provision does not apply to grade C.

2. *Sharp edges on fastenings.*—Tie wires or fastenings shall have no sharp edges or burrs at contacts with the conductors.

3. *Height of pin.*—The height of the pin and the conductor fastenings and the material and cross section of the pin should be chosen so as to afford the required strength.

Note.—The method of attaching conductors by suitable ties to single pin-type insulators mounted on 1½ by 9 inch wood pins of locust or equivalent wood will usually provide strength up to 1,000 pounds conductor tension with the conductor 3.5 inches above the cross arm. Steel pins may afford greater strength both for the pins and for the cross arms.

F. Open supply conductors.

1. *Material.*—Conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

Recommendation.—It is recommended that medium-hard-drawn copper wire (conforming to the specifications of the American Society for Testing Materials) be used instead of soft in new construction, especially for sizes smaller than No. 2.

Note.—Soft copper wire has a yield point less than one-half that of medium-drawn copper, and hence stretches permanently with a correspondingly lighter loading of ice and wind.

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 to increase materially under moderate loading of ice and wind.

2. *Minimum sizes of supply conductors.*—Supply conductors shall be not smaller than indicated in Table 23.

Exception 1.—Longer spans than specified in the table may be used with any listed conductor size if the separations and clearances of section 23 and the sags of Appendix B are correspondingly increased.

Exception 2.—Supply service leads of 0 to 750 volts may have the sizes set forth in rule 263, E.

Exception 3.—Where the short-span method of construction is employed in accordance with rule 261, K, the conductor sizes and sags herein specified are not required.

Table 23.—Minimum Allowable Conductor Sizes

[Sizes are A. W. G. for copper, copper-covered steel, and aluminum; Stl. W. G. for steel]

Kind of wire	Loading district	Grade of construction	Wire sizes for span lengths up to and including the following limits (in feet)								
			150	175	200	250	300	400	500	700	1,000
Covered wires: Copper, medium or hard drawn. Copper-covered steel.	Heavy	A and B	6	4	4	----	2	----	----	----	----
		C	8	6	4	----	2	----	----	----	----
	Medium	A	6	4	4	----	2	----	----	----	----
		B	8	6	4	----	2	----	----	----	----
		C	8	6	4	----	2	----	----	----	----
	Light	A	6	6	4	----	2	----	----	----	----
		B	8	6	6	----	2	----	----	----	----
		C	8	8	6	----	2	----	----	----	----
Bare wires: Copper, medium or hard drawn. Copper-covered steel.	Heavy	A and B	6	4	4	----	4	2	2	----	----
		C	8	6	4	----	4	2	2	----	----
	Medium	A	6	6	4	----	4	4	2	2	00
		B	8	6	4	----	4	4	2	2	00
		C	8	6	4	----	4	4	2	2	00
	Light	A	6	6	6	----	4	4	4	2	1
		B	8	6	6	----	4	4	4	2	1
		C	8	8	6	----	4	4	4	2	1
Covered or bare wires: Copper, soft-drawn.	Heavy	A	4	2	1	----	----	----	----	----	----
		B	4	2	2	----	----	----	----	----	----
		C	6	2	2	----	----	----	----	----	----
	Medium	A and B	4	4	2	1	----	----	----	----	----
		C	6	4	2	1	----	----	----	----	----
	Light	A, B, and C	6	4	4	2	1	----	----	----	----
				Exceeding 150							
Steel wire.	All	A and B	6	4							
		C	9	6							
Stranded aluminum wire: Without steel reinforcement.	All	A, B, and C	1	0							
With steel reinforcement.	All	A, B, and C	6	4							

3. *Lightning protection wires.*—Lightning protection wires paralleling the line conductors shall be regarded in respect to size, material, separation, and stringing requirements as supply conductors with which they are associated.

4. *Sags and tensions.*

(*a*) MINIMUM ALLOWABLE SAG.

Conductor sags shall be such that, under the assumed loading of rule 253 for the district concerned, the tension in the conductor shall not be more than 50 per cent of its breaking strength for grades A and B, nor more than 60 per cent for grade C.

NOTE.—The sag tables of Appendix B are based upon a stringing temperature of 30, 60, or 90° F. to comply with these requirements.

Recommendation.—It is recommended that conductors of hard, medium, and soft drawn copper have normal sags, at 60° F. and no wind, as near as practicable to those given in the tables of Appendix A.

NOTE.—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.

In order to minimize the danger from wires swinging together and to permit the moderate pin spacings and cross-arm spacings sanctioned by modern good practice in overhead line construction, it is necessary to assign a limit to the sag, and hence to the recommended length of span of the smaller-sized wires, as indicated by the blank spaces in the tables.

(*b*) TWO-THOUSAND-POUND LIMITATION FOR CONDUCTOR TENSIONS.

In order to apply the methods given in rule 261, D, 3, (*d*), and rule 261, E, 1, (*d*), it is necessary that conductor tensions be limited to 2,000 pounds. The curves given in Appendix C show sags based on these limitations for conductors having an ultimate strength of 4,000 pounds or more.

5. *Splices and taps.*

Grades A and B.—Splices shall not be made in the crossing span and preferably not in the adjacent spans, which are depended upon for withstanding the longitudinal tension of the crossing conductors. Taps shall not be made in the crossing span. If a splice or tap is made in any conductor in the span next to the crossover span, it shall, where practicable, be placed at a point nearer to the crossover support than is the nearest conductor crossed over.

Exception.—In the case of large-gauge conductors where the application of this rule would work a hardship and where proper methods are available for making high-strength splices, such splices may be used in the crossing span provided they are of a type which has been shown by tests and experience to be at least as strong as the conductor.

Grade C.—The above does not apply to grade C.

6. *Trolley contact conductors.*—In order to provide for wear, no trolley contact conductor shall be installed of less size than No. 0 if of copper or No. 4 if of silicon bronze.

G. Supply cables.

1. *Specially installed supply cables.*—Cables having permanently grounded continuous metal sheath or armor, where located on jointly used poles, or where located on other poles and having a grade of construction less than that required for open-wire supply lines of the same voltage, shall meet the requirements of (*a*), (*b*), (*c*), and (*d*) below.

(*a*) MESSENGERS.

Messengers shall be stranded and of galvanized or copper-covered steel with strengths and sags as specified in rule 262, J, for grade D, or if of other sizes shall not be stressed beyond half their ultimate strength under the loadings specified in rule 253.

(*b*) GROUNDING OF CABLE SHEATH AND MESSENGER.

Each section of cable between splices shall be suitably and permanently bonded to the messenger wire at not less than two places. The messenger wire shall be grounded at the ends of the line, and at intermediate points not exceeding 800 feet apart. (See section 9 for method.)

(*c*) CABLE SPLICES.

Splices in the cable shall be made so that their insulation is not materially weaker than the remainder of the cable. The sheath or armor at the splice shall be made electrically continuous.

(*d*) CABLE INSULATION.

The conductors of the cable shall be insulated so as to withstand a factory potential test of at least twice the operating voltage at operating frequency applied continuously for five minutes between conductors and between any conductor and the sheath or armor.

2. *Other supply cables.*—The following requirements apply to all supply cables not included in 1 above.

(*a*) MESSENGER.

The messenger shall have such strength and sag that it will not be stressed beyond the following percentages of its ultimate strength under the loadings specified in rule 253:

Grade of construction.	Percentage of ultimate strength
A and B	50
C	60

(*b*) CABLE.

There are no strength requirements for cables supported by messengers.

H. Open communication conductors.—Open-wire communication conductors in grade A, B, or C construction shall have the sizes and sags given in rule 261, F, 2 and 4, for supply conductors of the same grade.

Exception.—Where the span length is 150 feet or less, conductors may have grade D sizes and sags instead of grade C sizes and sags, except as provided in note *g* to Table 15, rule 242.

I. Communication cables.

1. *Metal-sheathed communication cables.*—There are no strength requirements for such cables supported by messengers..

2. *Messenger.*—The messenger shall have such strength and sag that it will not be stressed beyond the following percentages of its ultimate strength under the loading specified in rule 253:

Grade of construction:	Percentage of ultimate strength
A and B	50
C	60

J. Paired communication conductors.

1. *Paired conductors supported on messenger.*

(*a*) USE OF MESSENGER.

A messenger may be used for supporting paired conductors in any location, but is only required for paired conductors crossing over trolley contact conductors of more than 7,500 volts.

(*b*) SAG OF MESSENGER.

Messenger used for supporting paired conductors required to meet grade A or B construction because of crossing over trolley contact conductors shall meet the sag requirements for grade D messengers.

(*c*) SIZE AND SAG OF CONDUCTORS.

There are no requirements for paired conductors when supported on messenger.

2. *Paired conductors not supported on messenger.*

(*a*) ABOVE SUPPLY LINES.

Grades A and B.—Sizes and sags shall not be less than those required by rule 261, F, 2 and 4, for supply conductors of similar grade.

Grade C.

Spans 0 to 100 feet, no sag requirements. Sizes shall be not less than the following:

Hard-drawn copper	No. 14 A. W. G.
Bronze	No. 17 A. W. G.
Copper-covered steel	No. 17 A. W. G.

Spans 100 to 150 feet, sizes and sags shall be not less than required for grade D communication conductors.

Spans exceeding 150 feet, sizes and sags shall be not less than required for grade C supply conductors.

(*b*) ABOVE TROLLEY CONTACT CONDUCTORS.

Grades A and B.—Sizes and sags shall not be less than the following:

Spans 0 to 100 feet, no size requirements. Sags shall be not less than for No. 8 A. W. G. hard-drawn copper as given in Appendix B.

Spans exceeding 100 feet, sizes shall be not less than the following:

Hard-drawn copper	No. 14 A. W. G.
Bronze	No. 17 A. W. G.
Copper-covered steel	No. 17 A. W. G

Sags shall be not less than for No. 8 A. W. G. hard-drawn copper as given in Appendix B.

Grade C.—Sizes and sags shall be as follows:

Spans 0 to 100 feet, no requirements.

Spans exceeding 100 feet, no sag requirements. Size shall be not less than the following:

Hard-drawn copper	No. 14 A. W. G.
Bronze	No. 17 A. W. G.
Copper-covered steel	No. 17 A. W. G.

K. Short-span crossing construction.—Where supply lines cross over railways or communication lines by the short-span method, the requirements for grade A, B, or C conductor sags and sizes are waived, in so far as such grades are required by the crossing, provided that a permanently grounded guard arm is installed at each crossover support in such a manner as to prevent conductors which break in either adjoining span from swinging back into the conductors crossed over, or in the case of a railroad crossing into the space between the crossing supports.

Explanation.—The short-span method of crossing requires the crossover span to be of such a height that a conductor breaking in that span can not come within 15 feet of the ground or rails at a railroad crossing or make contact with any wires crossed over at a wire crossing.

This character of construction is facilitated where the crossover supports can be placed quite near together and in the case of wire crossings where the span crossed over is at a minimum elevation above ground.

L. Cradles at supply-line crossings.—Cradles should not be used.

NOTE.—It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

M. Protective covering or treatment for metal work.—All hardware, including bolts, washers, guys, anchor rods, and similar parts of material subject to injurious corrosion under the prevailing conditions, shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

262. Grades D and E Construction.

A. Poles.

1. *Strength of unguyed poles.*—Unguyed poles, at the time of installation, shall withstand the vertical and transverse

loads specified in rule 254, A and B, and the longitudinal loads specified in rule 254, C, without exceeding the following percentages of their ultimate strength:

	Percentages of ultimate strength for different grades	
	Grade D	Grade E
For transverse strength	25	37.5
For longitudinal strength (for poles carrying not more than two wires)	50	75

2. *Strength of guyed poles.*—Where poles are guyed, the poles shall be considered as acting as struts, resisting the vertical component of the tension in the guy calculated as in rule 262, C, combined with the vertical load.

3. *Strength requirements for poles where guying is required, but can only be installed at a distance.*—Where on account of physical conditions it is impracticable to guy or brace the crossing poles as specified in rule 262, C, the requirements there given may be met by head-guying and side-guying the line as near as practicable to the crossing, but at a distance not exceeding 500 feet from the nearest crossing pole, provided that the line is approximately straight and that a stranded steel wire of strength equivalent to that of the head guy is run between the two guyed poles, being attached to the guyed poles at the point at which the head guys are attached, this wire being securely attached to every pole between the guyed poles.

4. *Pole locations at crossings.*—Where communication lines cross over railroads, the poles shall be located as follows:

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

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

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

6. *Minimum pole sizes.*—Poles shall have top diameters not smaller than the values given in Table 24 below:

Table 24.—Minimum Pole Sizes for Grades D and E

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

7. *Spliced poles.*—Spliced poles shall not be used at grade D or E crossings or conflicts.

8. *Poles located at crossings over spur tracks.*—Where a communication line paralleling a railroad track on the right of way of the railroad crosses a spur or stub track without any change in the general direction of line, the transverse strength requirements for grade E construction may be met without the use of side guys, providing the pole is not stressed beyond one-half its ultimate strength. No requirements for longitudinal strength are made if the conductor tensions are balanced. Where conductor tensions are not balanced, due

to a small angle in the line at one or both poles, or to dead-ending any of the wires, either guys or braces shall be installed capable of withstanding such unbalanced tensions.

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

Average length of span:	Allowable vertical distance *Feet*
Less than 100 feet	4
100 to 130 feet	5
Exceeding 130 feet	6

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

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

C. Guys.

1. *General.*—The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (sec. 28).

2. *Where used.*—Side guys or braces shall be used on poles supporting the crossing span to withstand the loads put upon them in accordance with the conditions specified in rule 254, B.

Head guys shall be installed in accordance with Table 25.

Exception 1.—Side guys are not required where the crossing poles have the transverse strength specified in rule 262, A, 1. Head guys are not required where the crossing poles carry not more than two wires and have the strength specified in rule 262, A, 1.

Exception 2.—This rule does not apply to crossing poles under the special conditions set forth in rule 262, A 3, above.

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

Exception 4.—Guying may be omitted where communication lines cross over spur or stub tracks as provided in rule 262, A, 8.

3. *Guys used for transverse strength.*—Guys shall be considered as taking the entire load in the direction in which they act, without exceeding the following percentages of the ultimate strength of the material.

	Per cent
Grade D	50
Grade E	75

4. *Guys used for longitudinal strength.*

(*a*) DIRECTION OF HEAD GUYS.

Poles supporting the crossing span shall be head-guyed away from the crossing.

(*b*) SIZE AND NUMBER OF HEAD GUYS.

Guys for various wire loads shall be supplied as per Table 25.

Exception.—This rule does not prevent the omission of head guys where the crossing poles have the strength specified in rule 262, A, 1, above and carry not more than two wires.

Table 25.—Strength (in Pounds) of Head Guys Required for Loading Districts Indicated

[Combinations of standard-size guys may be used]

Number of wires	Ratio of guy lead to height not less than—				
	1¼	1	¾	⅔	½
GRADE D, HEAVY LOADING					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	6,000
10	6,000	6,000	6,000	10,000	10,000
20	10,000	10,000	12,000	16,000	16,000
30	16,000	16,000	20,000	20,000	26,000
40	20,000	20,000	26,000	26,000	32,000
50	20,000	20,000	30,000	32,000	42,000
60	26,000	30,000	36,000	36,000	48,000
70	30,000	30,000	40,000	48,000	60,000
80	36,000	40,000	48,000	60,000	70,000
GRADE D, MEDIUM LOADING, AND GRADE E, HEAVY LOADING					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	4,000
10	4,000	4,000	6,000	6,000	6,000
20	6,000	10,000	10,000	10,000	12,000
30	10,000	10,000	12,000	16,000	16,000
40	12,000	16,000	16,000	16,000	20,000
50	16,000	16,000	20,000	20,000	26,000
60	20,000	20,000	26,000	26,000	30,000
70	20,000	20,000	26,000	30,000	36,000
80	26,000	26,000	30,000	32,000	40,000
GRADE D, LIGHT LOADING, AND GRADE E, MEDIUM LOADING					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	4,000
10	4,000	4,000	4,000	4,000	4,000
20	4,000	6,000	6,000	6,000	10,000
30	6,000	10,000	10,000	10,000	12,000
40	10,000	10,000	10,000	12,000	16,000
50	10,000	10,000	16,000	16,000	20,000
60	12,000	16,000	16,000	16,000	20,000
70	16,000	16,000	20,000	20,000	26,000
80	16,000	20,000	20,000	26,000	30,000

See note on p. 176.

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Table 25.—Strength (in Pounds) of Head Guys Required for Loading Districts Indicated—Continued.

Number of wires	Ratio of guy lead to height not less than—				
	1¼	1	¾	⅔	½
GRADE E, LIGHT LOADING					
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	4,000
10	4,000	4,000	4,000	4,000	4,000
20	4,000	4,000	4,000	4,000	6,000
30	6,000	6,000	6,000	6,000	10,000
40	6,000	6,000	10,000	10,000	10,000
50	6,000	6,000	10,000	10,000	12,000
60	10,000	10,000	10,000	12,000	16,000
70	10,000	10,000	12,000	16,000	16,000
80	10,000	12,000	16,000	16,000	20,000

NOTE.—This table is based on ultimate or breaking strength of guys equal to seven-sixths of the nominal strengths shown in the table and a wire load of 50 per cent No. 8 B. W. G. iron and 50 per cent No. 9 A. W. G. copper with an average pull of 408.75 pounds per wire. No guy will be required for cable, since the suspension strand serves as a head guy.

5. *Location of guy anchors.*—Guy anchors shall, where possible, be located so that the horizontal distance from the ground line of the pole to the guy or guy rod will be not less than the height above ground of the attachment of the guy to the poles for head guys, and not less than one-third that height for side guys.

6. *Attachment of guys to poles.*—The guys shall be attached as near to the center of the load as practicable.

7. *Maintenance.*—The guys and anchors shall be maintained so that the guys are kept taut.

D. Cross arms.

1. *Material.*—Wood cross arms supporting the crossing span shall be of yellow pine, fir, or other suitable timber.

2. *Minimum size.*

(*a*) WOOD CROSS ARMS.

Wood cross arms shall have a cross section not less than the following:

Length of arm:	Cross section (inches)
6 feet or less	2¾ by 3¾
More than 6 feet	3 by 4

Exception.—In rural districts in arid regions where the practice has been established of using 2¾ by 3¾ inch arms in 8 and 10 pin lengths, this practice may be continued where conductors are not larger than No. 10.

(*b*) STEEL OR IRON CROSS ARMS.

Galvanized or painted iron or steel cross arms of strength equal to wood cross arms may be used.

3. *Double cross arms.*—Cross arms and insulators shall be double on the crossing poles. The cross arms shall be held together with properly fitted spacing blocks or bolts placed immediately adjoining the outside pins. Double cross arms shall not support more than 10 conductors.

E. Brackets and racks.—Brackets or racks may be used only if used in duplicate or otherwise designed so as to afford two points of support for each conductor.

Exception.—For supporting paired conductors, a single metal bracket, designed to safely withstand the full dead-end pull of the wires, may be used.

F. Pins.

1. *Material.*—Insulator pins shall be of steel, wrought iron, malleable cast iron, or locust or equivalent wood.

2. *Strength.*—Insulator pins shall have sufficient strength to withstand the loads to which they may be subjected.

3. *Size.*

(*a*) WOOD PINS.

Wood pins shall be sound and straight-grained with a diameter of shank not less than 1¼ inches.

(*b*) METAL PINS.

Steel or iron pins shall have diameter of shank not less than one-half inch.

G. Insulators.—Each insulator shall be of such pattern, design, and material that when mounted it will withstand, without injury and without being pulled off the pin, the ultimate strength of the conductor attached to the insulator.

H. Attachment of conductor to insulator.—The conductors shall be securely tied to each supporting insulator.

I. Conductors.

1. *Material.*—Conductors shall be of hard-drawn copper, copper-covered steel, galvanized steel, or other hard-drawn corrosion-resisting metal, provided, however, that galvanized steel shall not be used in localities where excessive corrosion would result.

2. *Size.*—Conductors of the crossing span, if of hard-drawn copper or galvanized steel, shall have sizes not less than specified in (*a*) and (*b*) below. Conductors of material other than the above shall be of such size and so erected as to have a mechanical strength not less than that of the sizes of copper conductors given in (*a*) and (*b*) below.

(*a*) SPANS NOT EXCEEDING 150 FEET.

The sizes in Table 26 apply.

Table 26.—Grades D and E Minimum Wire Sizes

[A. W. G. for copper; Stl. W. G. for steel]

Conductor	Loading district	Spans of 125 feet or less		Spans 125 feet to 150 feet	
		Grade D	Grade E	Grade D	Grade E
Copper, hard-drawn	Heavy	10	10	9	10
	Medium	10	12	9	10
	Light	10	12	9	10
Steel, galvanized:					
In general	All	10	12	8	10
In rural districts of arid regions	All	12	12	10	10

(*b*) SPANS EXCEEDING 150 FEET.

If spans in excess of 150 feet are necessary, the size of conductors specified above or the sags of the conductors shall be correspondingly increased.

3. *Paired conductors without messengers.*—Paired wires without a supporting messenger shall be eliminated as far as practicable and where used shall meet the following requirements:

(*a*) MATERIAL.

Each conductor shall be made of bronze, hard-drawn copper, or copper-covered steel, and shall be tinned.

(*b*) SIZE.

Each wire shall be not smaller than the following:

Hard-drawn copper	No. 14 A. W. G.
Bronze	No. 17 A. W. G.
Copper-covered steel	No. 17 A. W. G.

(*c*) LIMITING SPAN LENGTHS.

Paired wires shall in no case be used without a supporting messenger in longer spans than the following:

	Feet
For grade D construction	100
For grade E construction	125

4. *Sags.*—Conductors of the crossing span shall be strung with sags not less than shown in Table 27.

Table 27.—Minimum Stringing Sags of Bare Hard-Drawn Copper Wire or Steel Wire for Loading Districts Indicated

HEAVY LOADING

Length of span (in feet)	Sag (in inches)					
	100° F.	80° F.	60° F.	40° F.	20° F.	0° F.
75	5½	5	4	3¼	2¾	2¼
80	6½	5½	4½	3½	3	2½
90	8	7	5½	4½	3½	3
100	10	8½	7	5½	4½	4
110	12	10	8½	6½	5½	5
120	14	12	10	8	6½	6
130	17	14	12	9½	8	7
140	20	17	14	11	9½	8
150	23	20	16	13	11	9

MEDIUM LOADING

	100° F.	80° F.	60° F.	40° F.	20° F.	0° F.
75	4	3½	3	2½	2¼	1¾
80	5	4	3½	3	2½	2
90	6	5	4	3½	3	2½
100	7½	6	5	4½	3½	3
110	9	7½	6	5½	4½	3¾
120	11	9	7	6½	5½	4½
130	13	10½	8½	7½	6½	5½
140	15	12	10	8½	7½	6½
150	17	14	12	10	8½	7½

LIGHT LOADING

	120° F.	100° F.	80° F.	60° F.	40° F.	20° F.
75	4	3½	3	2½	2	1¾
80	5	4	3½	3	2½	2
90	6	5	4	3½	3	2½
100	7	6	5	4	3½	3
110	8½	7	6	5	4	3½
120	10	8½	7	6	5	4
130	12	10	8½	7	6	5
140	14	12	10	8½	7	6
150	16	14	12	10	8	7

5. *Splices and taps.*—Splices and taps shall not be made in the crossing span and preferably not in the adjacent spans.

6. *Simultaneous crossing over railroad and supply line.*—Where conductors cross in the same span over a railroad track and a supply line carrying from 750 volts alternating current (440 volts to neutral or ground) to 5,000 volts alternating current (2,900 volts to neutral or ground) the minimum allowable conductor sizes shall be the same as required by rule 261, F, 2, for grades A and B construction when crossing main and minor tracks, respectively.

J. Messengers.

1. *Minimum size.*

(*a*) SPANS NOT EXCEEDING 150 FEET.

Table 28 gives the minimum sizes of galvanized steel-strand messenger to be used for supporting different sizes of cables:

Table 28.—Minimum Sizes of Messenger

Size of cable in weight per foot	Messenger (nominal breaking load)
	Pounds
Less than 2.25 pounds	6,000
2.25 to 5 pounds	10,000
Exceeding 5 and less than 8 pounds	16,000

(*b*) SPANS EXCEEDING 150 FEET.

For spans exceeding 150 feet or for heavier cables a proportionately larger messenger or other proportionately stronger means of support shall be used.

2. *Sags and tensions.*—Multiple-wire cables and their messengers shall be suspended with a normal sag at 60° F., so that when they are subjected to the loading prescribed in rule 253 the tension in the messenger will not exceed the following values of safe working tension.

Table 29.—Safe Working Tension in Messengers

Nominal breaking load of messenger (in pounds)	Safe working tension of messenger
	Pounds
6,000	3,500
10,000	5,900
16,000	9,500

K. Inspection.—All parts of the supporting structures of the crossing span shall be examined annually by the owner and all defective parts shall be promptly restored to a safe condition.

263. Grade N Construction.

A. Poles and towers.—Poles used for lines for which neither grade A, B, C, D, or E is required shall be of such initial size and so guyed or braced, where necessary, as to withstand safely the loads to which they may be subjected, including linemen working on them.

B. Guys.—The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (sec. 28).

C. Cross-arm strength.—Cross arms shall be securely supported, by bracing if necessary, so as to support safely loads to which they may be subjected in use, including linemen working on them. Any cross arm, or buck arm, except the top one, shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

Note.—Double cross arms are generally used at crossings, unbalanced corners, and dead ends in order to permit conductor fastenings at two insulators, and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used, and cross-arm guys are sometimes used.

D. Supply-line conductors.

1. *Material.*—All supply conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

2. *Size.*—Supply-line conductors shall be not smaller than the following:

Table 30.—Grade N Minimum Gauge Sizes for Supply-Line Conductors

[A. W. G. for copper and aluminum; Stl. W. G. for steel]

	Urban	Rural
Soft copper	6	8
Medium or hard-drawn copper	8	8
Steel	9	9

Stranded aluminum	Urban and rural	
	Spans 150 feet or less	Spans exceeding 150 feet
Not reinforced	1	0
Steel-reinforced	6	4

Recommendation.—It is recommended that except as modified in Table 23, rule 261, F, 2, these minimum sizes for copper and steel be not used in spans longer than 150 feet for heavy-loading districts, and 175 feet for medium and light loading districts.

E. Supply services.

1. *Material.*—All supply service conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

2. *Size of open-wire services.*

(*a*) SEVEN HUNDRED AND FIFTY VOLTS OR LESS.

Supply service leads of 750 volts or less shall be not smaller than required by (1) or (2) below.

(1) SPANS NOT EXCEEDING 150 FEET.

Table 31.—Minimum Sizes of Service Leads Carrying 750 Volts or Less

[A. W. G. for copper; Stl. W. G. for steel]

Situation	Copper wire		Steel wire
	Soft drawn	Medium or hard drawn	
Alone	10	12	12
Concerned with communication conductors	10	12	12
Over supply conductors of—			
0 to 750 volts	10	12	12
750 to 7,500 volts [a]	8	10	12
Exceeding 7,500 volts [a]	6	8	9
Over trolley contact conductors—			
0 to 750 volts a. c. or d. c.	8	10	12
Exceeding 750 volts d. c.	6	8	9

[a] Installation of service leads of not more than 750 volts over supply lines of more than 750 volts should be avoided where practicable.

(2) SPANS EXCEEDING 150 FEET.—Sizes shall not be smaller than required for grade C. (Rule 261, F, 2.)

(*b*) EXCEEDING 750 VOLTS.

Sizes of supply service leads of more than 750 volts shall be not less than required for supply line conductors of the same voltage.

3. *Sag, open-wire services.*

(*a*) SEVEN HUNDRED AND FIFTY VOLTS OR LESS.

Supply service leads of 750 volts or less shall have sags not less than the following:

Table 32.—Sags for Open-Wire Services

Span lengths (in feet)	Sag
	Inches
100 or less	12.
100 to 125	18.
125 to 150	27.
Exceeding 150	Grade C sags. (See tables of Appendix B.

(*b*) EXCEEDING 750 VOLTS.

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

4. *Cabled services.*—Supply service leads may be grouped together in a cable, provided the following requirements are met.

(*a*) SIZE.

The size of each conductor shall be not less than required for leads of separate conductors. (Rule 263, E, 2.)

(*b*) SAG.

The sag of the cable should be not less than required for leads of separate conductors. (Rule 263, E, 3.)

(*c*) INSULATION.

The insulation should be sufficient to withstand twice the normal operating voltage.

F. Lightning protection wires.—Lightning protection wires paralleling the line conductors shall be regarded, in respect to size and material requirements, as supply conductors.

G. Trolley contact conductors.—In order to provide for wear, no trolley contact conductors shall be installed of less size than No. 0, if of copper, or No. 4, if of silicon bronze.

H. Cradles at supply-line crossings.—Cradles should not be used.

NOTE.—It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

I. Communication conductors.—There are no specific requirements for grade N communication line conductors or service drops.

SEC. 27. LINE INSULATORS

270. Application of Rule.

These requirements apply only to situations where grade A or B construction is required. They do not apply to line insulators in grade C, D, E, or N construction.

271. Material and Marking.

Insulators for operation on supply lines at voltages of 2,300 and above shall be of porcelain, made by the wet process or one equally suitable as regards electrical and mechanical properties, or other material which will give equally good results in respect to mechanical and electrical performance and durability. These insulators should be marked by the maker with a classification number and maker's name or trade-mark, the marks being applied so as not to reduce the electrical or mechanical strength of the insulator.

272. Electrical Strength of Insulators in Strain Position.

Where insulators are used in strain position they shall have not less electrical strength than the insulators generally used on the line when under the normal mechanical stresses imposed by the loadings specified in section 25.

273. Ratio of Flash Over to Puncture Voltage.

Insulators shall be designed so 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.

274. Test Voltages.

Insulators when tested under American Institute of Electrical Engineers' specifications shall flash over at values not less than given in Table 33.

Table 33.—Test Voltage Requirements

[Based on line conditions of rule 276, B, 1]

Nominal line voltage	Minimum test dry flash-over voltage of insulators	Nominal line voltage	Minimum test dry flash-over voltage of insulators
750	5,000	55,000	150,000
2,300	20,000	66,000	175,000
4,000	30,000	88,000	220,000
6,600	40,000	110,000	315,000
11,000	50,000	132,000	390,000
22,000	75,000	150,000	420,000
33,000	100,000	200,000	560,000
44,000	125,000		

(Interpolate for intermediate values.)

275. Factory Tests.

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

276. Selection of Insulators.

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

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

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

2. Where operating conditions are more severe than set forth in 1 above, due to steel construction, extent of system, use of ungrounded neutral, prevalence of exceptionally severe lightning, bad atmosphere due to chemical fumes, smoke, cement, dust, salt fog, or other foreign matter, or to a long dry season with heavy dust accumulation followed by moisture, larger insulators than the minimum specified in Table 33 should be used. The amount of increase is to be determined by local experience.

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

Exception.—The 25 per cent increase does not apply if all the insulators in the line are of the suspension type or if construction in accordance with rule 278 below is employed.

277. 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.

278. Compliance with Rule 277 at Crossings.

At crossings, construction in accordance with the following methods will be considered as a means of meeting the requirements of rule 277 above.

A. Pin-type insulators.

1. *Double construction.*—Double cross arms, pins, insulators, and conductor fastenings on the crossing supports.

2. *Insulation at crossing supports.*

(*a*) Insulators which meet the minimum values as given in Table 33 and have a rating not less than those in the remainder of the line, under the following conditions:

(1) Wood pins, ungrounded at the crossing supports, with wood or metal pins grounded or ungrounded throughout the line.

(*b*) Insulators which have a rating of 25 per cent greater than the requirements of Table 33, but not less than the insulators in the remainder of the line, under the following conditions:

(1) Wood pins, grounded at the crossing supports and throughout the line.

(2) Metal pins, grounded or ungrounded at crossing supports and throughout the line.

(*c*) Insulators at the crossing support which have a rating 50 per cent greater than those in the rest of the line, but not less than 25 per cent greater than required by Table 33 under the following conditions:

(1) Wood pins, grounded at crossing support and pins ungrounded throughout the remainder of the line.

(2) Metal pins, grounded at the crossing support and pins ungrounded throughout the remainder of the line.

(3) Metal pins, ungrounded at the crossing support with wood pins ungrounded throughout the remainder of the line.

B. Suspension insulators.

1. *Double cross arms.*—Double cross arms on crossing supports.

Exception.—This does not apply to latticed or trussed steel cross arms nor to steel cross arms used with a single string of insulators as per 2 (*b*) following.

2. *Number of insulator strings.*

(*a*) DOUBLE INSULATOR STRINGS.

Double strings of the insulators used on the crossing supports except under the special conditions covered in (*b*) following.

(*b*) SINGLE INSULATOR STRINGS.

Where preferred single strings of insulators may be used if all the following conditions obtain.

(1) Steel cross arms on steel poles or structures.

(2) Hardware throughout providing a factor of safty of not less than 2 against the assumed maximum tension in the conductor in one direction.

(3) A high-strength clamp which will prevent the conductor under assumed maximum loading conditions from slipping into the crossing span.

(4) An extra unit where strings of five or less are used elsewhere in the line and two extra units where strings of six or more are normally used, these extra units to be provided in addition to those in 4 below.

3. *Position of insulator strings.*—Insulators of the suspension type on crossing supports preferably should be used in the supension or semistrain position except where conditions are such as to require the insulators to be used in the full-strain position.

4. *Insulators in suspended position.*

(*a*) UNGROUNDED CROSSING SUPPORTS.

Insulators which meet the requirements of Table 33. In all cases the insulation at the crossing to be at least equal to that elsewhere in the line.

(*b*) GROUNDED SUPPORTS AT THE CROSSING AND ELSEWHERE IN THE LINE.

Where supports throughout the line are grounded, insulators which meet the requirements of Table 33 with one extra unit in each string normally requiring five or less and two extra units in each string normally requiring six or more; in all cases the insulation at the crossing to be at least equal to that elsewhere in the line.

(*c*) GROUNDED SUPPORTS AT CROSSINGS ONLY.

Insulator strings which have one extra unit where the strings in other portions of the line normally have five or less and two extra units where the strings elsewhere in the line have six or more units; in all cases the insulators to meet (*b*) above.

5. *Insulators in strain position.*—Where insulators are used in the strain position one more unit than in 4 above to be used in each string.

6. *Limit for increased number of insulators.*—In no case is the application of the above paragraphs to result in the addition of more than two disks to strings normally requiring five or less, nor more than three disks to strings normally requiring six or more.

SEC. 28. MISCELLANEOUS REQUIREMENTS FOR OVERHEAD LINES

280. Supporting Structures.

A. Poles and towers.

1. *Rubbish.*—Poles and towers shall be placed, guarded, and maintained so as to be exposed as little as practicable to brush, grass, rubbish, or building fires.

2. *Guarding poles.*

(*a*) PROTECTION AGAINST MECHANICAL INJURY.

Where poles and towers are exposed to abrasion by traffic or to other damage which would materially affect their strength, they shall be protected by guards.

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(*b*) PROTECTION AGAINST CLIMBING.

On closely latticed poles or towers carrying supply conductors exceeding 300 volts to ground, either guards or warning signs shall be used except as follows:

Exception 1.—Where the right of way is completely fenced.

Exception 2.—Where the right of way is not completely fenced, provided the poles or towers are not adjacent to roads, regularly traveled thoroughfares, or places where people frequently gather, such as schools or public playgrounds.

3. *Warning signs.*

(*a*) ON POLES OR TOWERS.

For warning signs on poles or towers, see rule 280, A, 2, (*b*).

(*b*) ON BRIDGE FIXTURES.

Structures attached to bridges for the purpose of supporting conductors shall be plainly marked with the name, initials, or trade-mark of the utility responsible for the attachment and, in addition, where the voltage exceeds 750 volts, by the following sign or its equivalent, "Danger—Do Not Touch."

4. *Grounding metal poles.*—Metal poles not guarded or isolated shall always be specially grounded where in contact with metal-sheathed cable or the metal cases of equipment operating at voltages exceeding 750 volts.

Metal poles not guarded, isolated, or specially grounded should always be considered as imperfectly grounded and the insulators supporting line conductors as well as the strain insulators in attached span wires should, therefore, have a suitable margin of safety and be maintained with special care to prevent leakage to the pole as far as practicable.

5. *Pole steps.*

(*a*) METAL STEPS.

Steps closer than 6½ feet from the ground or other readily accessible place shall not be placed on poles.

(*b*) WOOD BLOCKS.

One wood block (or on private right of way more than one) may be placed on poles carrying communication cables or paired conductors below supply conductors; but the lowest block is not to be less than 3½ feet from the ground or other readily accessible place. On poles carrying only communication conductors, additional wood blocks may be used.

6. *Identification of poles.*—Poles, towers, and other supporting structures on which are maintained electrical conductors shall be so constructed, located, marked, or numbered as to facilitate identification by employees authorized to work thereon. Date of installation of such structures shall be recorded where practicable by the owner.

7. *Obstructions.*—All poles should be kept free from posters, bills, tacks, nails, and other unnecessary obstructions, such as through bolts not properly trimmed.

B. Cross arms.

1. *Location.*—In general, cross arms should be maintained at right angles to the axis of the pole and to the direction of the attached conductors, and at crossings should be attached to that face of the structure away from the crossing, unless special bracing or double cross arms are used.

NOTE.—Double cross arms are generally used at crossings, unbalanced corners, and dead ends in order to permit conductor fastenings at two insulators and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used and cross arm guys are sometimes used.

2. *Bracing.*—Cross arms shall be securely supported, by bracing if necessary, so as to support safely loads to which

they may be subjected, including linemen working on them. Any cross arm or buck arm, except the top one, shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

C. Unusual conductor supports.—Where conductors are attached to structures other than those used solely or principally for supporting the lines, all rules shall be complied with as far as they apply, and such additional precautions as may be deemed necessary by the administrative authority shall be taken to avoid injury to such structures or to the person using them. The supporting of conductors on trees and roofs should be avoided where practicable.

281. Tree Trimming.

A. General.—Where trees exist near supply line conductors, they shall be trimmed, if practicable, so that neither the movement of the trees nor the swinging or increased sagging of conductors in wind or ice storms or at high temperatures will bring about contact between the conductors and the trees.

Exception.—For the lower-voltage conductors, where trimming is difficult, the conductor may be protected against abrasion and against grounding through the tree by interposing between it and the tree a sufficiently nonabsorptive and substantial insulating material or device.

B. At wire crossings and railroad crossings.—The crossing span and the next adjoining spans shall be kept free, as far as practicable, from overhanging or decayed trees which might fall into the line.

282. Guying.

A. Where used.—When the 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.

Guys shall be used also, where necessary, wherever conductor tensions are not balanced, as at corners, angles, dead ends, and changes of grade of construction.

Note.—This is to prevent undue increase of sags in adjacent spans as well as to provide sufficient strength for those supports on which the loads are considerably unbalanced.

B. Strength.—The strength of the guy shall meet the requirements of section 26 for the grade of construction that applies.

When guys are used with wood or other poles or towers capable of considerable deflection before failure, the guys shall be able to support the entire load in the direction in which they act, the pole acting simply as a strut.

C. Point of attachment.—The guy should be attached to the structure as near as practicable to the center of the conductor load to be sustained.

D. Guy fastenings.—Guys should be standard and where attached to anchor rods should be protected by suitable guy thimbles or their equivalent. Cedar and other softwood poles to which any guy having a strength of 10,000 pounds or more is attached should be protected by the use of suitable guy shims, and where there is a tendency for the guy to slip off the shim, guy hooks or other suitable means of preventing this action should be used. Shims are not necessary in the case of supplementary guys, such as storm guys.

E. Guy guards.—The ground end of all guys attached to ground anchors exposed to traffic shall be provided with a substantial and conspicuous wood or metal guard not less than 8 feet long.

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

F. Insulating guys from metal poles.—Where anchors would otherwise be subject to electrolysis, guys attached to metal poles or structures and not containing guy insulators should be insulated from the metal pole or structure by suitable blocking.

G. Anchor rods.—Anchor rods shall be installed so as to be in line with the pull of the attached guy when under load, except in rock or concrete. The anchor rod shall have an ultimate strength in the eye and shank equal to that required of the guy.

H. Grounding.—The anchored end of guys attached to wood poles carrying circuits of more than 15,000 volts shall be permanently grounded (see section 9 for method) wherever this part of the guy has a clearance of less than 8 feet to ground.

Exception 1.—This does not apply to guys in rural districts.

Exception 2.—This does not apply if the guy contains an insulator which will meet the requirements of rule 283, A, 2, for the highest voltage liable to be impressed on it.

283. Guy Insulators.

A. Properties of guy insulators.

1. *Material.*

(*a*) GRADES A AND B.

Guy insulators shall be made by the wet porcelain process or a process equally suitable as regards electrical and mechanical properties.

(*b*) GRADES C, D, E, AND N.

No requirements are made for material.

2. *Electrical strength.*—Guy insulators shall have a dry flash-over voltage at least double the normal line voltage

and a wet flash-over voltage at least as high as the normal line voltage between conductors.

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

B. Use of guy insulators.

1. *One insulator.*—An insulator shall be located in each guy which is attached to a pole or structure carrying any supply conductors of more than 300 volts to ground and not more than 15,000 volts between conductors, or in any guy which is exposed to such voltages. This guy insulator shall be located from 8 to 10 feet above the ground.

Exception.—A guy insulator is not required where the guy is grounded under the conditions set forth in 4 following.

2. *Two insulators.*—Where a guy attached to any pole carrying communication or supply conductors, or both, is carried over or under overhead supply conductors of more than 300 volts to ground and where hazard would otherwise exist, two or more guy insulators shall be placed so as to include the exposed section of the guy between them as far as possible. Neither insulator shall be within 8 feet of the ground.

Exception.—These insulators are not required where the guy is grounded under the conditions set forth in 4 following.

3. *Relative location of insulators in guys located one above the other.*—Where guys in which it is necessary to install insulators are so arranged that one crosses or is above another, insulators shall be so placed that in case any guy sags down upon another the insulators will not become ineffective.

4. *Conditions not requiring guy insulators.*—Insulators are not required in guys under the following conditions:

(*a*) Where the guy is electrically connected to grounded steel structures or to a ground connection on wood poles.

(*b*) Where the guys are uniformly permanently grounded throughout any system of overhead lines.

284. Span-wire Insulators.

A. Mechanical strength.—Span-wire insulators shall have a mechanical strength at least equal to that required of the span wire in which they are installed.

B. Use of span-wire insulators.—All span wires, including bracket span wires, shall have a suitable strain insulator (in addition to an insulated hanger if used) inserted between each point of support of the span wire and the lamp or trolley contact conductor supported, except that single insulation, as provided by an insulated hanger, may be permitted when the span wire or bracket is supported on wooden poles supporting only trolley, railway feeder, or communication conductors used in the operation of the railway concerned. In case insulated hangers are not used, the strain insulator shall be located so that in the event of a broken span wire the energized part of the span wire can not be reached from the ground.

Exception.—This rule does not apply to insulated feeder taps used as span wires.

285. Conductors.

A. Identification.—All conductors of electrical supply and communication lines should be arranged to occupy definite positions throughout, as far as practicable, or shall be so constructed, located, marked, or numbered as to facilitate identification by employees authorized to work thereon. This does not prohibit systematic transposition of conductors.

B. Branch connections.

1. *Accessibility.*—Connections of branches to supply circuits, service loops, and equipment in overhead construction shall be readily accessible to authorized employees. When possible, connections shall be made at poles or other structures.

2. *Clearance.*—Branch connections shall be supported and placed so that swinging or sagging can not bring them in contact with other conductors, or interfere with the safe use of pole steps, or reduce the climbing or lateral working space.

286. Equipment on Poles.

A. Identification.—All equipment of electrical supply and communication lines should be arranged to occupy definite positions throughout, as far as practicable, or shall be constructed, located, marked, or numbered so as to facilitate identification by employees authorized to work thereon.

B. Location.—Transformers, regulators, lightning arresters, and switches when located below conductors or other attachments shall be mounted outside of the climbing space.

C. Guarding.—Current-carrying parts of switches, automatic circuit-breakers, and lightning arresters shall be suitably inclosed or guarded if all the following conditions apply:

1. If of more than 300 volts to ground; and

2. If located on the climbing side of the pole less than 20 inches from the pole center; and

3. If located below the top cross arm.

D. Hand clearance.—All current-carrying parts of switches, fuses, lightning arresters, also transformer connections and other connections which may require operation or adjustment while alive and are exposed at such times, shall be arranged so that in their adjustment while alive the hand need not be brought nearer to any other current-carrying part at a different voltage than the clearances from pole surfaces required in Table 9, rule 235, A, 3, (*a*), for conductors of corresponding voltages. (See also rules 422, A, B, and C, part 4, for clearances from live parts.)

E. Street-lighting equipment.

1. *Clearance from pole surface.*—All exposed metal parts of lamps and their supports (unless effectively insulated from the current-carrying parts) shall be maintained at the following distances from the surface of wood poles:

	Inches
(*a*) In general	20
(*b*) If located on the side of the pole opposite the designated climbing side	5

Exception.—This does not apply where lamps are located at pole tops.

2. *Clearance above ground.*—Street lamps shall be mounted at not less than the following heights above ground:

	Feet
(*a*) Over walkways	10
(*b*) Over roadways:	
Connected to circuits of 150 volts or less	14
Connected to circuits of more than 150 volts	15

3. *Horizontal clearances.*—Arc and incandescent lamps in series circuits should have at least 3 feet horizontal clearance from windows, porches, and other spaces accessible to the general public.

4. *Material of suspension.*—The lowering rope or chain for lighting units, arranged to be lowered for examination or maintenance, shall be of a material and strength designed to withstand climatic conditions and to sustain the lighting unit safely. The lowering rope or chain, its supports and fastenings, shall be examined periodically.

5. *Insulators in suspension ropes.*—Effective insulators as specified in rule 283, A, should be inserted at least 8 feet from the ground in metallic suspension ropes or chains supporting lighting units of series circuits.

6. *Arc-lamp disconnectors.*—A suitable device shall be provided by which each arc-lighting unit on series circuits of more than 300 volts to ground may be safely and entirely

disconnected from the circuit before the lamp is handled, unless the lamps are always worked on from suitable insulating stools, platforms, or tower wagons, or handled with suitable insulating tools, and treated as under full voltage of the circuit concerned.

287. Protection for Exposed Communication Lines.

A. Open wire.—Communication lines for public use and fire-alarm lines shall be treated as follows if at any point they are exposed to supply (including trolley) lines of more than 400 volts to ground.

1. At stations for public use they shall be protected by one of the methods specified in part 3, section 39.

2. Elsewhere they shall be isolated by elevation or otherwise guarded so as to be inaccessible to the public.

B. Metal-sheathed cable.—Metal-sheathed cables and messengers shall be isolated or grounded in conformity with the general requirements of section 21.

288. Communication Circuits Used Exclusively in the Operation of Supply Lines.

A. Choice of method.—Communication circuits used exclusively in the operation of supply lines may be run either as ordinary communication circuits or as supply circuits under the conditions specified in rule 288, C and D, respectively. After selection of the type of communication-circuit construction and protection for any section which is isolated, or is separated by transformers, such construction and protection shall be consistently adhered to throughout the extent of such isolated section of the communication system.

B. Guarding.—Communication circuits used in the operation of supply lines shall be isolated by elevation or otherwise guarded at all points so as to be inaccessible to the public.

C. Where ordinary communication line construction may be used.—Communication circuits used in the operation of supply lines may be run as ordinary communication conductors under the following conditions:

1. Where such circuits are below supply conductors in the operation of which they are used (including high-voltage trolley feeders) at crossings, conflicts, or on commonly used poles, provided:

(*a*) Such communication circuits occupy a position below all other conductors or equipment at crossings, conflicts, or on commonly used poles.

(*b*) Such communication circuits and their connected equipment are adequately guarded and are accessible only to authorized persons.

(*c*) The precautions of section 39, part 3, and section 44, part 4, have been taken.

2. Where such circuits are below supply conductors in the operation of which they are used and are above other supply or communication conductors at wire crossings, conflicts, or on the same poles, provided the communication circuits are protected by fuseless lightning arresters, drainage coils, or other suitable devices to prevent the communication circuit voltage from normally exceeding 400 volts to ground.

NOTE.—The grades of construction for communication conductors with inverted levels apply.

D. Where supply line construction must be used.—Communication circuits used in the operation of supply lines shall comply with all requirements for the supply lines with which they are used, where they do not comply with the provisos of C, 1, above or the proviso of C, 2, above.

Exception 1.—Where the voltage of the supply conductors concerned exceeds 7,500, the communication conductors need only meet the requirements for a 7,500-volt supply circuit.

Exception 2.—Where the supply conductors are required to meet grade C, the size of the communication conductors may be the same as for grade D (see rule 262, I, 2) for spans up to 150 feet.

289. Electric-railway Construction.

A. Trolley contact conductor supports.—All overhead trolley contact conductors shall be supported and arranged so that the breaking of a single contact conductor fastening will not allow the trolley conductor, live span wire, or current-carrying connection to come within 10 feet (measured vertically) from the ground, or from any platform accessible to the general public.

Span-wire insulation for trolley contact conductors shall comply with rule 284.

B. High-voltage contact conductors.—Every trolley contact conductor of more than 750 volts in urban districts where not on fenced right of way shall be suspended so as to minimize the liability of a break and, as far as practicable, so that if broken at a single point it can not fall within 12 feet (measured vertically) from the ground or any platform accessible to the general public.

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

D. Prevention of loss of contact at railroad crossings.—Trolley contact conductors shall be arranged as set forth in either 1 or 2 following, at grade crossings with interurban or other heavy-duty or high-speed railroad systems.

1. The trolley contact conductor shall be provided with live trolley guards of suitable construction, or,

2. The trolley contact conductor shall be as far as practicable at the same height above its own track throughout the crossing span and the next adjoining spans. Where a

uniform height above rail is not adhered to, the change shall be made in a very gradual manner. Where the crossing span exceeds 100 feet, catenary construction shall be used.

Exception.—This rule does not apply where the system is protected by interlocking derails or by gates.

E. Guards under bridges.

1. *Where guarding is required.*—Guarding is required where the trolley contact conductor is so located that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

2. *Nature of guarding.*—Guarding shall consist of a substantial inverted trough of nonconducting material located above the contact conductor, or other suitable means of preventing contact between the trolley pole and the bridge structure.

SEC. 29. RULES FOR UNDERGROUND LINES

290. Location of Duct Systems and Manholes.

A. General location.—Underground systems of electrical conductors should be located so as to be subject to the least practicable disturbance. All railway tracks and all underground structures, including catch basins, gas pipes, etc., should be avoided where practicable. Conductors and cables carried underground under railways shall be placed in suitable ducts.

B. Ducts.—The ducts between adjacent manholes or other outlets should be installed in straight lines. If curves are necessary, they should be of the longest practicable radius, and the spacing between adjacent manholes should be reduced proportionately.

C. Manholes.—Manholes shall, where practicable, be located so as to provide convenient access and so that the least horizontal distance from any track rail to the nearest edge of the manhole opening will be not less than 3 feet. At crossings under railroads, manholes, pull boxes, and terminals shall be located away from the roadbed (preferably outside the fenced right of way).

291. Construction of Duct Systems.

A. Material, size, and finish of ducts.—Ducts shall be of such material, size, mechanical strength, and finish as to facilitate the installation and maintenance of conductors or cables. Ducts shall be freed from burrs before laying and shall have clear bores.

B. Grading of ducts.—Grade of ducts shall be such as to drain toward manholes or handholes. A grade of not less than 3 inches in 100 feet of length shall be provided where practicable.

C. Alignment of ducts.—Ducts shall be laid so as to prevent inside shoulders at joints.

D. Duct joints.—Joints in duct runs shall be made mechanically secure to maintain individual ducts in alignment.

E. Protection.

1. *Settling.*—Ducts should be suitably reinforced or be laid on suitable foundations of sufficient mechanical strength where necessary to protect them from settling.

2. *Damage.*—Ducts should be protected by concrete or other covering where necessary to prevent being damaged by workmen when digging, or by other causes.

F. Clearances.

1. *General.*—The clearances between duct systems and other underground structures, particularly gas lines paralleling them, shall be as great as practicable. The distance between the top covering of the duct system and the pavement surface, or other surface under which the duct system is constructed, shall be sufficient to protect the duct system from injury.

2. *Railroad tracks.*—The distance between the top of the duct system structure and the base of the rail shall be not less than 30 inches in the case of street railways and not less than 42 inches in the case of steam and electric railroads.

Exception 1.—Where the ballast section subject to working and cleaning is less than 42 inches, the clearance may be reduced for street railways to not less than 18 inches; and for steam and electric railroads to not less than 30 inches; but in no case to less than the depth of ballast section plus 6 inches. In lieu of the additional depth of 6 inches, a 1½-inch creosoted plank, or 3 inches of concrete, or iron pipe may be provided.

NOTE.—The above clearances are based on a duct system the width of which is not more than 3 creosoted wood ducts, 4 vitrified clay ducts, 4 impregnated fiber ducts, or 4 iron or mild-steel pipes. These clearances do not apply to bridge-type structures designed to sustain the weight of the roadbed and the operating load.

When a wider duct system is contemplated, additional strength of construction and protection should be provided, or the duct system should be placed at a greater depth.

Where unusually hard digging, as in rock, or when obstructions are encountered, a conduit run may be spread to a width of six ducts, so as to maintain the required clearance beneath the base of the rail.

Exception 2.—Where physical and chemical conditions will permit, a duct system consisting of not more than two iron pipes, not exceeding 3 inches in diameter, or two creosoted wood ducts, not exceeding 4½ inches square, used for communication lines or for service supply lines not exceeding 750 volts, may be laid in the ground beneath the tracks without any other form of protection at a depth not less than 18 inches below the base of the rail unless the worked ballast section of the roadbed exceeds 18 inches, in which case the duct system shall be laid below the ballast section.

G. Separation between supply and communication duct systems.

1. *General.*—Duct systems, including laterals, to be occupied by communication conductors for public use should be separated, where practicable, from duct systems, including laterals, for supply conductors by not less than 3 inches of concrete, 4 inches of brick masonry, or 12 inches of well-tamped earth.

Exception.—Extensions may, however, be made to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, communication companies, or power companies with less effective separations than above specified.

2. *Entering manholes.*—Where communication conductors and supply conductors occupy ducts terminating in the same manhole, the two classes of ducts should be separated as widely as practicable and where practicable should enter the manhole at opposite sides.

Explanation.—This requirement is made so that cables can be racked along side walls with a minimum of crosses between the two classes of conductors.

H. Duct entrances into manholes.

1. *Clearances.*—Duct entrances into manholes should, where practicable, have a clearance above the floor or below the roof line of not less than 6 inches, and from either side wall of at least 4 inches.

2. *Smooth outlet.*—Iron-pipe conduit terminating in manholes, handholes, or other permanent openings of underground systems shall be provided with an effective shield, bushing, or other smooth outlet.

I. Sealing laterals.—Lateral ducts for service connections to buildings, through which gas or water may enter build-

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ings or other duct systems should be effectively plugged or cemented by the use of asphaltum, pitch, or other suitable means.

J. Duct arrangement for dissipation of heat.—Duct systems intended to carry supply cables of large current capacity should be arranged, where practicable, so that ducts carrying such cables will not dissipate their heat solely through other ducts.

292. Construction of Manholes.

A. Minimum strength.—The design and construction of manholes and handholes shall provide sufficient strength to sustain with a suitable margin of safety the loads which may reasonably be imposed on them.

B. Dimensions.—Manholes should meet the following requirements where practicable:

1. *Width.*—The least horizontal inside dimension should be not less than 3 feet 6 inches.

2. *Working space.*—A clear working space should be provided. The horizontal dimension should be not less than 3 feet. The vertical dimension should be not less than 6 feet except in manholes where the opening is within 1 foot on each side of the full size of the manhole.

Exception.—The dimensions specified in 1 and 2 above are not necessary in service boxes, handholes, or in manholes serving a small number of ducts, or in manholes used exclusively for communication system equipment and cables.

C. Drainage.—Where drainage is into sewers, suitable traps shall be provided to prevent entrance of sewer gas into manholes.

D. Ventilation.—Adequate ventilation to open air shall be provided for manholes from which any openings exist into subways entered by the public.

Exception.—Subways under water or in other locations where it is impracticable to comply.

E. Manhole openings.—The opening to any manhole should be not less than 24 inches minimum dimension.

Recommendation.—Round openings are recommended.

F. Manhole covers.—Manholes and handholes, while not being worked in, shall be securely closed by covers of sufficient strength to sustain such loads as reasonably may be imposed upon them.

G. Supports for cables.—Supports shall be provided, where necessary, for all cables at each manhole, handhole, or other permanent opening.

NOTE.—In handholes which reach the top line of ducts only, or in small manholes, the duct line itself may serve as sufficient support for the cables.

293. Manhole Location.

Manhole openings shall, where practicable, be located so that barriers or other suitable guards can be placed to protect the opening effectively when uncovered.

294. Location of Conductors.

A. Accessibility.—Cables in manholes shall be reasonably accessible from the clear working space at all times. When cables pass by or cross over other cables, sufficient clearance shall be provided between them to prevent abrasion and to permit reasonable access to any cable for inspection or repair.

B. Clearance from manhole floor.—Each cable shall be maintained at a vertical clearance above the manhole floor of at least 6 inches, where practicable.

C. Conductors carrying large currents.—Conductors intended to carry large currents should be located, where practicable, in outside ducts so that they will not necessarily dissipate heat solely through adjacent ducts.

D. Separation between conductors.

1. *Cables of different voltages.*—Cables shall be arranged and supported in ducts and manholes so that those operating

at higher voltages will be separated as far as practicable from those operating at lower voltages.

2. *Cables of different systems.*—Cables belonging to different systems, particularly supply distribution and communication systems, shall not be installed in the same duct.

3. *Conductors of supply and communication systems.*

(*a*) GENERAL.

Supply conductors and communication conductors for public use should, in general, be maintained in separate duct systems, and particularly in separate manholes.

Exception.—Cable extensions may be made to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, communication companies, or power companies.

(*b*) IN THE SAME MANHOLE.

Supply conductors and communication conductors for public use occupying the same manhole should be maintained at opposite sides of the manhole. Where supply and communication cables must cross, a separation of at least 1 foot shall be maintained.

295. Protection of Conductors in Duct Systems and Manholes.

A. Protection against moisture.—Cables shall be provided with a water-tight metal sheath or other waterproof covering over their insulating coverings.

Exception.—This requirement does not apply to rubber-insulated cables nor to cables used as ground connections or neutrals.

B. Protection against arcing.—A suitable fire-resisting covering should be placed on the following cables to prevent injury from arcing:

1. Closely grouped lead-sheathed supply cables of more than 7,500 volts, or of large current capacity operating at more than 750 volts a. c. or 300 volts d. c.

2. Communication cables and supply cables of large current capacity if they are within the same manhole and within arcing distance of each other.

3. Communication cables and supply cables which cross each other in the same manhole. In this case the protective covering above specified is mandatory.

C. Mechanical protection.

1. *Crossings of supply and communication cables.*—Special mechanical protection shall be provided against abrasion where supply and communication conductors must cross in the same manhole.

2. *Iron-pipe conduit.*—Iron-pipe conduit, terminating in manholes, handholes, or other permanent openings of underground systems, shall be provided with an effective shield, bushing, or other smooth outlet.

296. Guarding of Live Parts in Manholes.

A. Conductor joints or terminals.—Joints or terminals of conductors or cables of supply systems shall be arranged so that there are no bare ungrounded current-carrying metal parts exposed to accidental contact within manholes or handholes.

B. Apparatus.

1. *General.*—Live parts of protective, control, or other apparatus of supply lines installed and maintained in manholes or handholes shall be inclosed in suitable grounded cases.

2. *Continuity between cable sheath and apparatus cases.*—The metal sheathing of all conductors or cables shall be made mechanically and electrically continuous with the metal cases of protective, control, or other apparatus.

297. Construction at Risers from Underground.

A. Separation between risers of communication and supply systems.—The placing of risers for communication systems and risers for supply systems on the same pole should be avoided where practicable. If it is necessary to use the same pole for the risers of both systems, they shall be placed on opposite semicircumferences of the pole where practicable.

B. Mechanical protection of conductors.—All conductors or cables from underground systems which connect to overhead systems shall be protected by a covering which gives suitable mechanical protection up to a point 8 feet above the ground.

Exception 1.—Armored cables or cables installed in a grounded metal conduit.

Exception 2.—Communication circuits on private fenced rights of way.

C. Grounding of riser pipes.—Exposed metal riser pipes containing supply conductors shall be grounded unless such conductors are covered with a grounded metal sheath or are themselves grounded.

D. Conductor terminal construction.—The terminals of underground cables operating at more than 750 volts to ground and connecting to overhead open-wire systems shall meet the following requirements:

1. *Protection against moisture.*—Protection shall be provided so that moisture will not enter the cable.

2. *Insulation of conductors.*—Conductors shall be properly insulated from the grounded metal sheath. In addition, the conductors of multiple conductor cable shall be properly separated and insulated from each other.

NOTE.—These requirements may be fulfilled by the use of potheads or other equivalent devices, such as oil switches, if incidentally they accomplish the same purpose.

E. **Clearance above ground for open supply wiring.**—Supply wires connecting to underground systems shall not be run open closer to the ground than is indicated by the following table:

Table 34.—Clearance Above Ground for Open Supply Wiring

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

298. Identification of Conductors.

Cables shall be permanently identified by tags or otherwise at each manhole, handhole, or other permanent opening of the underground system.

Exception.—This requirement does not apply where the position of a cable, in conjunction with diagrams supplied to workmen, gives sufficient identification, or where the manhole is occupied solely by the communication cables of one utility.

299. Identification of Apparatus Connected in Multiple.

Where transformers, regulators, or other similar apparatus not located in the same manhole operate in multiple, special tags, diagrams, or other suitable means shall be used to indicate that fact.

Exception.—This requirement does not apply where disconnecting devices are provided to permit cutting such equipment completely off the system.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

APPENDIXES TO PART 2
NATIONAL ELECTRICAL SAFETY CODE

Appendix A.—RECOMMENDED NORMAL SAGS OF COPPER OVERHEAD LINE CONDUCTORS, WITH CORRESPONDING TENSIONS AND STRESSES

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 large conductors will sometimes be advisable, to reduce the loads on poles at turns and dead ends, and to permit smaller longitudinal guys where such guying is called for by the rules. (See rule 254 C.)

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. Simple and fairly accurate methods for measuring sags will be given in a future supplementary volume.

The sags are intended to apply to both solid and stranded conductors. The corresponding tensions and stresses, however, have been computed only for solid conductors.

Table 35.—Sags for Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths

[At 30, 60, and 90° F.—wires without load]

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—								
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		° F.	In.	In.	In.	In.	In.	In.	In.	In.	In.
8	C	30	8	11	22	-----	-----	-----	-----	-----	-----
		60	12	18	27	-----	-----	-----	-----	-----	-----
		90	16	22	32	-----	-----	-----	-----	-----	-----
6	A	30	8	11	22	-----	-----	-----	-----	-----	-----
		60	12	18	27	-----	-----	-----	-----	-----	-----
		90	16	22	32	-----	-----	-----	-----	-----	-----
6	B	30	6	10.5	16	-----	-----	-----	-----	-----	-----
		60	10	15	22	-----	-----	-----	-----	-----	-----
		90	14	19.5	27	-----	-----	-----	-----	-----	-----
6	C	30	6	10.5	16	28	-----	-----	-----	-----	-----
		60	10	15	22	33	-----	-----	-----	-----	-----
		90	14	19.5	27	39	-----	-----	-----	-----	-----
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	-----	-----
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
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
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
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
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 35.—Sags for Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths—Continued

MEDIUM LOADING DISTRICTS

Size A.W.G. No.	Grade of construction	Temperature	Sags for span length of—										
			100 feet	125 feet	150 feet	175 feet	200 feet	250 feet	300 feet	400 feet	500 feet	700 feet	1,000 feet
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
8	C	30	5.5	8.5	13	-----	-----	-----	-----	-----	-----	-----	-----
		60	8	12	18	-----	-----	-----	-----	-----	-----	-----	-----
		90	12	17	23.5	-----	-----	-----	-----	-----	-----	-----	-----
6	All	30	5.5	8.5	13	18.5	-----	-----	-----	-----	-----	-----	-----
		60	8	12	18	24	-----	-----	-----	-----	-----	-----	-----
		90	12	17	23.5	30	-----	-----	-----	-----	-----	-----	-----
4	All	30	5.5	8.5	13	18.5	25	35	61	134	-----	-----	-----
		60	8	12	18	24	32	42	69	141	-----	-----	-----
		90	12	17	23.5	30	39	50	77	149	-----	-----	-----
2	All	30	5.5	8.5	13	16.5	20	29	41	78	139	313	-----
		60	8	12	18	22	26	36	50	88	150	324	-----
		90	12	17	23.5	28	33	44	58	100	161	334	-----
1	All	30	5.5	8.5	13	15.5	18.5	24.5	32	62	111	275	-----
		60	8	12	18	21	24	31	40	72	124	286	-----
		90	12	17	23.5	28	31	39	48	83	135	298	-----
0	All	30	5.5	8.5	13	15.5	18	23.5	29	54	95	218	-----
		60	8	12	18	20.5	23	29	37	64	108	239	-----
		90	12	17	23.5	27.5	29.5	36	44	74	120	253	-----
00	All	30	5.5	8.5	13	15	17	21.	27	47	80	177	396
		60	8	12	18	20	22	27	33	55	92	192	415
		90	12	17	23.5	26	28	34	41	65	104	208	429
0000	All	30	5.5	8.5	13	14.5	16	19	23	41	66	140	304
		60	8	12	18	19	21	24	27	48	76	154	323
		90	12	1	23.5	25	27	30	33	57	88	171	340

Table 35.—Sags for Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths—Continued

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—										
			100 feet	125 feet	150 feet	175 feet	200 feet	250 feet	300 feet	400 feet	500 feet	700 feet	1,000 feet
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
8	C	30	4.5	6.5	9.5	15	----	----	----	----	----	----	----
		60	6	9	13	20	----	----	----	----	----	----	----
		90	9	13	18	26	----	----	----	----	----	----	----
6	All	30	4.5	6.5	9.5	13.5	18.5	----	----	----	----	----	----
		60	6	9	13	18	24	----	----	----	----	----	----
		90	9	13	18	24	30	----	----	----	----	----	----
4	All	30	4.5	6.5	9.5	13.5	17	20	32	69	126	----	----
		60	6	9	13	18	22	25	40	80	137	----	----
		90	9	13	18	24	28	32	48	90	148	----	----
2	All	30	4.5	6.5	9.5	13.5	14	16.5	24.5	50	86	193	----
		60	6	9	13	18	18	20	30	59	98	208	----
		90	9	13	18	24	23.5	25	37	69	110	222	----
1	All	30	4.5	6.5	9.5	13.5	14	16.5	23	44	74	163	362
		60	6	9	13	18	18	20	28	52	85	178	380
		90	9	13	18	24	23.5	25	34	61	96	193	396
0	All	30	4.5	6.5	9.5	13.5	14	16.5	23	41	68	146	316
		60	6	9	13	18	18	20	27	49	79	159	335
		90	9	13	18	24	23.5	25	33	58	89	175	353
00	All	30	4.5	6.5	9.5	13.5	14	16.5	22	39	62	125	276
		60	6	9	13	18	18	20	26	46	72	140	290
		90	9	13	18	24	23.5	25	32	54	83	154	309
0000	All	30	4.5	6.5	9.5	13.5	14	16.5	20	37	57	113	225
		60	6	9	13	18	18	20	24	43	66	126	246
		90	9	13	18	24	23.5	25	29	51	76	141	264

Table 36.—Sags for Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths

[At 30, 60, and 90° F.—wires without load]

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
8	C	30	15	23	36	------	------	------	------
		60	18	27	40	------	------	------	------
		90	21.5	31	44	------	------	------	------
6	A	30	15	23	36	------	------	------	------
		60	18	27	40	------	------	------	------
		90	21.5	31	45	------	------	------	------
6	B	30	11	17.5	27	------	------	------	------
		60	15	22	33	------	------	------	------
		90	18	26	38	------	------	------	------
6	C	30	8.5	14	22	31	------	------	------
		60	12	18	27	36	------	------	------
		90	15.5	22.5	32	40	------	------	------
4	All	30	8.5	14	21.5	31	43	------	------
		60	12	18	27	36	48	------	------
		90	17	22.5	32	41	54	------	------
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
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
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
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
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 36.—Sags for Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths—Continued

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F.	In.	In.	In.	In.	In.	In.	In.
8	C	30	11.5	18	29				
		60	15	22	33				
		90	18.5	26	37				
6	A	30	11.5	18	28				
		60	15	22	33				
		90	18.5	26	37				
6	B	30	8.5	14	22	31			
		60	12	18	27	36			
		90	15.5	22	32	41			
6	C	30	7.5	11	17.5	25			
		60	10	15	22	30			
		90	13.5	19	27	36			
4	All	30	7	11.5	17.5	24	33		
		60	10	15	22	30	39		
		90	13.5	19.5	27	36	45		
2	All	30	7	11.5	17.5	22.5	26	43	68
		60	10	15	22	27	32	50	76
		90	13.5	19.5	27	34	38	57	83
1	All	30	7	11	17	19.5	23.5	33	52
		60	10	15	22	25	29	39	60
		90	14	19.5	27	30	35	46	68
0	All	30	7	11	17.5	19.5	21.5	30	46
		60	10	15	22	24	27	36	54
		90	14	19.5	27	31	33	43	62
00	All	30	7	11	17	19	21	27	40
		60	10	15	22	24	26	33	48
		90	14	19.5	27	30	32	40	56
0000	All	30	7	11	17	18	19	23.5	33
		60	10	15	22	23	24	29	40
		90	13.5	19.5	27	29	30	35	47

Table 36.—Sags for Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths—Continued

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F.	In.	In.	In.	In.	In.	In.	In.
8	C	30	8.5	14	22.5	31	-------	-------	-------
		60	12	18	27	36	-------	-------	-------
		90	15.5	22.5	32	41	-------	-------	-------
6	A	30	8.5	14	22	31	-------	-------	-------
		60	12	18	27	36	-------	-------	-------
		90	15.5	22.5	32	41	-------	-------	-------
6	B	30	7	11.5	17.5	25	32	-------	-------
		60	10	15	22	30	38	-------	-------
		90	13	19.5	27	36	44	-------	-------
6	C	30	6	9	14	19.5	26	-------	-------
		60	8	12	18	24	32	-------	-------
		90	11	16	22.5	29	38	-------	-------
4	All	30	6.5	9	14	19	26	-------	-------
		60	8	12	18	24	32	-------	-------
		90	11.5	16	22	30	38	-------	-------
2	All	30	6.5	9	14	17.5	21	28	45
		60	8	12	18	22	26	34	52
		90	11.5	16	22	27	32	41	60
1	All	30	5.5	9	13.5	16.5	19	26	38
		60	8	12	18	21	24	31	45
		90	11.5	16	23	26	30	38	53
0	All	30	5.5	9	14	16.5	18	24.5	34
		60	8	12	18	21	23	30	41
		90	11.5	16.5	23	27	28	36	47
00	All	30	5.5	9	13.5	16	17.5	23	31
		60	8	12	18	20	22	28	37
		90	11.5	16	23	25	28	35	45
0000	All	30	5.5	8.5	13.5	16	16.5	20.5	27
		60	8	12	18	19	21	25	32
		90	11	16	23	24.5	26	31	39

55862°—27——16

Table 37.—Sags for Soft-Drawn Covered Copper Wires for Different Span Lengths

[At 30, 60, and 90° F.—wires without load]

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—				
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.
		°F	In.	In.	In.	In.	In.
6	C	30	18	28	44	--------	--------
		60	21	32	48	--------	--------
		90	24	36	51	--------	--------
4	A	30	17.5	28	45	--------	--------
		60	21	32	48	--------	--------
		90	24	35	51	--------	--------
4	B and C	30	14.5	23	36	--------	--------
		60	18	27	40	--------	--------
		90	21.5	31	44	--------	--------
2	A	30	14.5	23	36	49	--------
		60	18	27	40	54	--------
		90	21.5	31	44	58	--------
2	B and C	30	11	17.5	28	40	55
		60	15	22	33	45	60
		90	18.5	26	38	50	64
1	A	30	10.5	17.5	28	40	55
		60	15	22	33	45	60
		90	18.5	26	37	50	65
1	B and C	30	8.5	13.5	21.5	31	43
		60	12	18	27	37	48
		90	15.5	22.5	32	42	53
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
00	All	30	8.5	13.5	20	28	36
		60	12	18	25	33	42
		90	15.5	22.5	30	38	48
0000	All	30	8.5	13.5	18.5	24.5	30
		60	12	18	24	30	36
		90	16	22.5	29	36	42

Table 37.—Sags for Soft-Drawn Covered Copper Wires for Different Span Lengths—Continued

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—					
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		°F.	In.	In.	In.	In.	In.	In.
6	C	30	14.5	22	36			
		60	18	27	40			
		90	21	31	44			
4	All	30	11	18	28	44		
		60	15	22	33	48		
		90	18.5	26	37	53		
2	All	30	8.5	13.5	22.5	31	43	
		60	12	18	27	36	48	
		90	15.5	22	32	41	53	
1	All	30	8.5	13.5	20	28	36	53
		60	12	18	25	33	42	60
		90	15.5	22.5	30	38	48	67
0	All	30	8.5	13.5	19	25	33	47
		60	12	18	24	31	39	54
		90	15.5	22.5	29	37	45	61
00	All	30	8.5	13.5	19	24.5	30	41
		60	12	18	24	30	36	48
		90	15.5	22.5	29	36	42	55
0000	All	30	8.5	13.5	18.5	24.5	30	41
		60	12	18	24	30	36	48
		90	16	22.5	29	36	42	55

Table 37.—Sags for Soft-Drawn Covered Copper Wires for Different Span Lengths—Continued

LIGHT LOADING DISTRICTS

Size A.W.G. No.	Grade of construction	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		°F.	In.	In.	In.	In.	In.	In.
6	A	30	14	23	36			
		60	18	27	40			
		90	21.5	31	44			
6	B and C	30	11	17.5	29			
		60	15	22	33			
		90	18.5	26	37			
4	All	30	8.5	13.5	20	26	36	
		60	12	18	25	32	42	
		90	15.5	22.5	30	37	47	
2	All	30	7	11	16	22	30	41
		60	10	15	21	27	36	48
		90	13.5	19.5	26	33	42	55
1	All	30	7	11	15	19.5	24	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49
0	All	30	7	11	15.5	20	24.5	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49
00	All	30	7	11	15	19.5	24	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49
0000	All	30	7	10.5	15.5	19.5	24	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49

Table 38.—Tensions in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 35

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—								
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		°F.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
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						
6	A	30 no load	150	145	120						
		60 no load	99	105	99						
		90 no load	74	85	86						
		0 loaded	570	630	670						
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						
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					
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		
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

Table 38.—Tensions in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 35—Continued

HEAVY LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—								
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		°F.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
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
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
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
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

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—										
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1,000 ft.
		°F.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
8	C	30 no load	140	140	130								
		60 no load	94	97	94								
		90 no load	63	71	73								
		15 loaded	330	360	390								
6	All	30 no load	230	220	200	200							
		60 no load	150	155	150	150							
		90 no load	100	110	115	125							
		15 loaded	430	470	500	540							
4	All	30 no load	360	360	320	320	300	340	280	230			
		60 no load	240	250	240	240	240	280	250	220			
		90 no load	160	180	185	200	200	240	220	200			
		15 loaded	580	630	660	690	720	820	820	810			
2	All	30 no load	570	570	510	550	600	650	650	620	540	480	
		60 no load	380	390	380	420	460	520	540	550	500	460	
		90 no load	260	280	300	290	370	430	470	460	470	450	
		15 loaded	830	860	900	970	1,050	1,150	1,250	1,350	1,350	1,350	
1	All	30 no load	720	710	650	740	840	950	1,050	980	850	680	
		60 no load	480	490	470	550	630	760	850	850	770	650	
		90 no load	320	360	370	420	490	610	700	740	700	620	
		15 loaded	1,000	1,050	1,050	1,150	1,300	1,500	1,650	1,700	1,700	1,600	
0	All	30 no load	910	900	820	940	1,050	1,300	1,450	1,400	1,250	1,050	
		60 no load	600	620	600	710	830	1,050	1,200	1,200	1,100	980	
		90 no load	400	450	470	540	650	830	980	1,050	1,000	930	
		15 loaded	1,200	1,250	1,250	1,450	1,550	1,850	2,050	2,200	2,100	2,100	
00	All	30 no load	1,150	1,150	1,050	1,250	1,400	1,750	2,000	2,050	1,850	1,650	1,550
		60 no load	760	780	750	920	1,100	1,400	1,650	1,750	1,650	1,550	1,450
		90 no load	510	570	590	720	850	1,150	1,350	1,500	1,450	1,450	1,400
		15 loaded	1,450	1,500	1,500	1,750	1,950	2,350	2,650	2,850	2,850	2,850	2,850

Table 38.—Tensions in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 35—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—										
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft	1,000 ft.
		° *F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0000	All	30 no load	1,800	1,800	1,650	2,050	2,400	3,150	3,800	3,800	3,650	3,350	3,150
		60 no load	1,200	1,250	1,200	1,550	1,800	2,500	3,200	3,200	3,150	3,050	3,000
		90 no load	810	900	940	1,200	1,400	2,000	2,600	2,700	2,750	2,750	2,850
		15 loaded	2,250	2,300	2,250	2,700	3,000	3,800	4,500	4,650	4,700	4,700	4,700

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft	1,000 ft.
8	C	30 no load	180	180	175	150	--------	--------	--------	--------	--------	--------	--------
		60 no load	125	130	130	115	--------	--------	--------	--------	--------	--------	--------
		90 no load	82	91	94	90	--------	--------	--------	--------	--------	--------	--------
		30 loaded	210	220	230	220	--------	--------	--------	--------	--------	--------	--------
6	All	30 no load	280	290	280	270	260	--------	--------	--------	--------	--------	--------
		60 no load	200	210	210	200	200	--------	--------	--------	--------	--------	--------
		90 no load	130	145	150	155	160	--------	--------	--------	--------	--------	--------
		30 loaded	310	340	340	350	350	--------	--------	--------	--------	--------	--------
4	All	30 no load	450	460	450	430	450	590	520	440	380	--------	--------
		60 no load	320	330	330	320	340	470	430	380	340	--------	--------
		90 no load	210	230	240	240	270	370	350	340	320	--------	--------
		30 loaded	490	500	510	510	540	700	660	630	610	--------	--------
2	All	30 no load	710	730	710	680	870	1,150	1,100	960	870	760	--------
		60 no load	510	520	520	510	670	940	900	820	770	710	--------
		90 no load	330	370	380	390	510	750	730	700	680	660	--------
		30 loaded	750	780	790	770	940	1,200	1,250	1,150	1,150	1,100	--------

1	All	30 no load	900	920	890	860	1,100	1,450	1,450	1,400	1,300	1,150	1,050
		60 no load	640	660	650	640	840	1,200	1,200	1,150	1,100	1,050	1,000
		90 no load	410	460	480	490	650	940	990	990	980	970	970
		30 loaded	940	970	980	940	1,200	1,500	1,550	1,550	1,550	1,500	1,450
0	All	30 no load	1,150	1,150	1,150	1,100	1,400	1,800	1,900	1,800	1,750	1,600	1,500
		60 no load	800	830	830	810	1,050	1,500	1,600	1,550	1,500	1,450	1,450
		90 no load	520	580	600	620	820	1,200	1,300	1,300	1,350	1,350	1,350
		30 loaded	1,200	1,200	1,200	1,200	1,450	1,900	2,050	2,050	2,000	2,000	2,050
00	All	30 no load	1,450	1,450	1,400	1,350	1,750	2,300	2,500	2,450	2,400	2,350	2,200
		60 no load	1,000	1,050	1,050	1,050	1,350	1,900	2,100	2,100	2,100	2,100	2,100
		90 no load	660	730	760	780	1,050	1,500	1,700	1,800	1,800	1,900	1,950
		30 loaded	1,500	1,500	1,500	1,450	1,800	2,350	2,600	2,650	2,650	2,700	2,750
0000	All	30 no load	2,200	2,350	2,250	2,150	2,750	3,650	4,300	4,200	4,200	4,150	4,250
		60 no load	1,600	1,650	1,650	1,650	2,100	3,000	3,600	3,550	3,600	3,700	3,900
		90 no load	1,050	1,150	1,200	1,250	1,650	2,400	2,950	3,000	3,150	3,350	3,650
		30 loaded	2,300	2,350	2,350	2,250	2,900	3,700	4,300	4,400	4,400	4,550	4,750

Table 39.—Tensions in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 36

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
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				
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				
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				
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			
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		
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
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
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
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
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

Table 39.—Tensions in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 36—Continued

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°*F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
8	C	30 no load	98	98	89	------	------	------	------
		60 no load	75	80	76	------	------	------	------
		90 no load	61	68	69	------	------	------	------
		15 loaded	330	400	390	------	------	------	------
6	A	30 no load	150	150	135	------	------	------	------
		60 no load	115	120	115	------	------	------	------
		90 no load	93	100	105	------	------	------	------
		15 loaded	420	460	480	------	------	------	------
6	B	30 no load	195	190	170	170	------	------	------
		60 no load	140	145	140	145	------	------	------
		90 no load	110	120	120	130	------	------	------
		15 loaded	450	490	520	550	------	------	------
6	C	30 no load	230	230	220	210	------	------	------
		60 no load	170	175	170	175	------	------	------
		90 no load	125	140	140	150	------	------	------
		15 loaded	480	530	560	590	------	------	------
4	All	30 no load	350	340	320	290	300	------	------
		60 no load	250	260	250	250	250	------	------
		90 no load	180	200	210	210	220	------	------
		15 loaded	620	680	710	750	780	------	------
2	All	30 no load	560	540	510	530	600	560	520
		60 no load	390	410	400	440	490	490	470
		90 no load	290	320	330	360	410	430	430
		15 loaded	870	930	950	1,050	1,150	1,200	1,200
1	All	30 no load	670	670	620	750	820	900	830
		60 no load	470	490	490	580	660	760	710
		90 no load	350	390	390	480	540	640	630
		15 loaded	1,000	1,100	1,100	1,250	1,350	1,550	1,550
0	All	30 no load	870	850	790	950	1,100	1,250	1,200
		60 no load	610	630	620	710	900	1,050	1,000
		90 no load	440	490	510	610	730	880	890
		15 loaded	1,250	1,300	1,300	1,500	1,700	1,950	1,950
00	All	30 no load	1,050	1,050	990	1,200	1,450	1,750	1,650
		60 no load	750	780	770	960	1,150	1,400	1,400
		90 no load	550	610	630	780	950	1,200	1,200
		15 loaded	1,500	1,550	1,500	1,750	2,000	2,350	2,400
0000	All	30 no load	1,700	1,650	1,500	1,950	2,400	3,050	3,100
		60 no load	1,150	1,200	1,200	1,550	1,900	2,450	2,600
		90 no load	840	920	970	1,250	1,550	2,100	2,200
		15 loaded	2,200	2,250	2,150	2,600	3,150	3,750	3,950

Table 39.—Tensions in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 36—Continued

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°*F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
8	C	30 no load	130	125	115	115			
		60 no load	94	97	94	96			
		90 no load	73	79	79	84			
		30 loaded	220	240	260	270			
6	A	30 no load	195	190	170	170			
		60 no load	140	150	140	145			
		90 no load	110	120	120	130			
		30 loaded	310	330	340	360			
6	B	30 no load	250	230	220	210	200		
		60 no load	170	175	175	170	180		
		90 no load	130	140	140	145	155		
		30 loaded	340	360	380	400	420		
6	C	30 no load	290	290	270	270	260		
		60 no load	210	220	210	220	210		
		90 no load	155	165	170	180	180		
		30 loaded	380	410	420	440	450		
4	All	30 no load	430	430	390	390	380		
		60 no load	310	320	310	310	310		
		90 no load	220	240	230	250	260		
		30 loaded	530	560	570	600	620		
2	All	30 no load	690	680	630	690	740	870	790
		60 no load	490	510	490	540	600	720	670
		90 no load	340	380	360	430	490	600	590
		30 loaded	770	810	810	900	970	1, 150	1, 100
1	All	30 no load	840	840	790	890	1, 000	1, 150	1, 100
		60 no load	600	620	600	700	790	960	950
		90 no load	410	460	470	560	640	790	810
		30 loaded	920	960	940	1, 050	1, 200	1, 400	1, 400
0	All	30 no load	1, 050	1, 050	990	1, 100	1, 350	1, 550	1, 600
		60 no load	760	790	750	890	1, 050	1, 250	1, 350
		90 no load	540	590	590	700	850	1, 050	1, 150
		30 loaded	1, 150	1, 200	1, 150	1, 300	1, 550	1, 750	1, 850
00	All	30 no load	1, 350	1, 350	1, 250	1, 450	1, 700	2, 050	2, 150
		60 no load	950	990	940	1, 150	1, 350	1, 650	1, 800
		90 no load	660	730	740	900	1, 100	1, 350	1, 550
		30 loaded	1, 300	1, 450	1, 400	1, 650	1, 900	2, 250	2, 400
0000	All	30 no load	2, 150	2, 100	1, 900	2, 400	2, 750	3, 500	3, 850
		60 no load	1, 450	1, 500	1, 450	1, 850	2, 200	2, 850	3, 200
		90 no load	1, 050	1, 100	1, 150	1, 450	1, 750	2, 350	2, 700
		30 loaded	2, 150	2, 200	2, 050	2, 500	2, 900	3, 700	4, 050

Table 40.—Tensions in Soft-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 37

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.
		°*F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
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		
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		
4	B and C	30 no load	175	165	155		
		60 no load	140	145	140		
		90 no load	115	130	130		
		0 loaded	720	770	800		
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	
2	B and 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
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
1	B and 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
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
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
0000	All	30 no load	1,350	1,350	1,400	1,450	1,550
		60 no load	960	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

Table 40.—Tensions in Soft-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 37—Continued

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—					
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		° *F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
6	C	30 no load	120	120	105			
		60 no load	95	99	96			
		90 no load	80	88	88			
		15 loaded	390	420	440			
4	All	30 no load	220	220	195	170		
		60 no load	165	175	170	160		
		90 no load	135	145	150	145		
		15 loaded	530	580	590	580		
2	All	30 no load	450	450	390	390	370	
		60 no load	330	340	330	330	330	
		90 no load	250	280	280	290	300	
		15 loaded	800	850	860	900	880	
1	All	30 no load	560	540	540	530	530	560
		60 no load	400	410	430	440	450	500
		90 no load	310	330	360	380	400	450
		15 loaded	920	970	1,050	1,050	1,100	1,200
0	All	30 no load	710	690	720	730	740	810
		60 no load	510	530	560	600	620	700
		90 no load	390	430	470	510	540	630
		15 loaded	1,100	1,150	1,250	1,300	1,350	1,500
00	All	30 no load	890	860	900	950	1,000	1,150
		60 no load	630	650	700	770	840	980
		90 no load	480	520	590	650	720	860
		15 loaded	1,300	1,350	1,400	1,500	1,650	1,850
0000	All	30 no load	1,350	1,350	1,400	1,450	1,550	1,750
		60 no load	960	1,000	1,100	1,200	1,300	1,500
		90 no load	730	810	900	1,000	1,100	1,300
		15 loaded	1,900	1,900	2,000	2,100	2,150	2,450

Table 40.—Tension in Soft-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 37—Continued

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—					
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		° *F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
6	A	30 no load	120	115	105			
		60 no load	95	99	97			
		90 no load	80	88	89			
		30 loaded	250	260	270			
6	B and C	30 no load	150	150	135			
		60 no load	115	120	115			
		90 no load	92	105	105			
		30 loaded	280	300	300			
4	All	30 no load	290	280	280	280	280	
		60 no load	210	220	220	230	230	
		90 no load	155	175	185	210	210	
		30 loaded	430	450	470	510	520	
2	All	30 no load	560	550	540	550	520	600
		60 no load	390	410	410	440	440	510
		90 no load	290	320	340	370	700	440
		30 loaded	680	710	740	770	780	900
1	All	30 no load	690	680	700	740	790	850
		60 no load	480	490	530	580	630	710
		90 no load	350	390	430	480	730	610
		30 loaded	790	830	890	950	1,050	1,150
0	All	30 no load	860	850	890	940	990	1,100
		60 no load	600	630	690	750	810	910
		90 no load	440	490	550	610	670	780
		30 loaded	980	1,000	1,100	1,150	1,250	1,350
00	All	30 no load	1,100	1,050	1,100	1,150	1,250	1,350
		60 no load	760	780	840	920	1,000	1,100
		90 no load	550	610	680	760	840	960
		30 loaded	1,150	1,200	1,300	1,350	1,450	1,600
0000	All	30 no load	1,700	1,650	1,700	1,800	1,900	2,050
		60 no load	1,150	1,200	1,300	1,400	1,550	1,700
		90 no load	840	930	870	1,150	1,250	1,450
		30 loaded	1,750	1,800	1,900	2,000	2,150	2,350

Table 41.—Stresses in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 35

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1,000 ft.
		°F.	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
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								
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								
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								
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							
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				
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		

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		
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		
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		
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, 000	24, 850		

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8	C	30 no load	10, 900	10, 850	9, 850								
		60 no load	7, 250	7, 500	7, 200								
		90 no load	4, 900	5, 450	5, 650								
		15 loaded	25, 200	27, 900	30, 200								
6	All	30 no load	10, 900	10, 850	9, 850	9, 600							
		60 no load	7, 250	7, 500	7, 200	7, 400							
		90 no load	4, 900	5, 450	5, 650	6, 000							
		15 loaded	20, 700	22, 700	24, 400	26, 000							
4	All	30 no load	10, 900	10, 850	9, 850	9, 600	9, 250	10, 450	8, 650	6, 950			
		60 no load	7, 250	7, 500	7, 200	7, 400	7, 250	8, 600	7, 600	6, 600			
		90 no load	4, 900	5, 450	5, 650	6, 000	6, 050	7, 250	6, 850	6, 250			
		15 loaded	17, 800	19, 300	20, 150	21, 300	22, 050	25, 000	25, 050	24, 700			
2	All	30 no load	10, 900	10, 850	9, 850	10, 650	11, 450	12, 400	12, 550	11, 900	10, 400	9, 190	
		60 no load	7, 250	7, 500	7, 200	8, 000	8, 900	10, 000	10, 300	10, 500	9, 650	8, 800	
		90 no load	4, 900	5, 450	5, 650	5, 650	7, 000	8, 150	8, 950	8, 900	9, 000	8, 600	
		15 loaded	15, 800	16, 550	17, 150	18, 600	20, 200	22, 400	23, 950	26, 000	25, 750	25, 500	

Table 41.—Stresses in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 35—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—										
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1,000 ft.
		°F.	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}
1	All	30 no load	10,900	10,850	9,850	11,250	12,700	14,500	15,900	14,950	12,950	10,300	--------
		60 no load	7,250	7,500	7,200	8,350	9,600	11,550	12,900	12,850	11,700	9,850	--------
		90 no load	4,900	5,450	5,650	6,450	7,500	9,350	10,700	11,200	10,700	9,500	--------
		15 loaded	15,050	15,900	16,200	17,900	19,500	22,700	24,900	26,250	25,800	24,750	--------
0	All	30 no load	10,900	10,850	9,850	11,350	12,900	15,550	17,600	17,150	15,250	12,550	--------
		60 no load	7,250	7,500	7,200	8,600	10,000	12,400	14,200	14,500	13,300	11,800	--------
		90 no load	4,900	5,450	5,650	6,500	7,850	10,000	11,800	12,500	12,000	11,150	--------
		15 loaded	14,600	15,250	15,300	17,200	18,900	22,050	24,650	26,350	25,600	25,300	--------
00	All	30 no load	10,900	10,850	9,850	11,750	13,550	16,900	19,200	19,750	17,850	16,000	14,750
		60 no load	7,250	7,500	7,200	8,800	10,450	13,300	15,650	16,750	15,700	14,800	14,100
		90 no load	4,900	5,450	5,650	6,900	8,150	10,800	12,750	14,300	13,900	13,850	13,650
		15 loaded	14,100	14,600	14,600	16,550	18,750	22,400	25,250	27,300	27,250	27,300	27,400
0000	All	30 no load	10,900	10,850	9,850	12,250	14,300	18,850	22,800	22,750	21,850	20,250	19,050
		60 no load	7,250	7,500	7,200	9,250	10,950	15,600	19,150	19,200	18,900	18,300	18,000
		90 no load	4,900	5,450	5,650	7,150	8,500	12,000	15,650	16,200	16,400	16,650	17,050
		15 loaded	13,550	14,000	13,500	16,300	18,000	22,850	27,150	28,000	28,200	28,200	28,450

LIGHT LOADING DISTRICTS

8	C	30 no load	13,700	14,000	13,550	11,750	--------	--------	--------	--------	--------	--------	--------
		60 no load	9,700	10,000	9,950	8,800	--------	--------	--------	--------	--------	--------	--------
		90 no load	6,300	7,000	7,250	6,900	--------	--------	--------	--------	--------	--------	--------
		30 loaded	16,200	17,150	17,950	17,250	--------	--------	--------	--------	--------	--------	--------
6	All	30 no load	13,700	14,000	13,550	13,000	12,450						
		60 no load	9,700	10,000	9,950	9,800	9,600	--------	--------	--------	--------	--------	--------
		90 no load	6,300	7,000	7,250	7,450	7,600	--------	--------	--------	--------	--------	--------
		30 loaded	15,250	16,350	16,600	16,750	17,000	--------	--------	--------	--------	--------	--------
4	All	30 no load	13,700	14,000	13,550	13,000	13,600	18,000	15,850	13,400	11,500		
		60 no load	9,700	10,000	9,950	9,800	10,500	14,400	12,950	11,550	10,500	--------	--------
		90 no load	6,300	7,000	7,250	7.450	8,200	11,400	10,700	10,300	9,750	--------	--------
		30 loaded	15,000	15,350	15,600	15,600	16,500	21,200	20,250	19,400	18,700	--------	--------
2	All	30 no load	13,700	14,000	13,550	13,000	16,600	21,900	21,100	18,400	16,700	14,650	--------
		60 no load	9,700	10,000	9,950	9,800	12,750	18,000	17,250	15,650	14,750	13,650	--------
		90 no load	6,300	7,000	7,250	7,450	9,850	14,300	14,000	13,450	13,100	12,700	--------
		30 loaded	14,350	15,000	15,050	14,700	18,050	23,450	23,500	22,400	21,900	21,100	--------
1	All	30 no load	13,700	14,000	13,550	13,000	16,600	21,900	22,350	21,000	19,500	17,800	16,000
		60 no load	9,700	10,000	9,950	9,800	12,750	18,000	18,500	17,650	16,950	15,800	15,250
		90 no load	6,300	7,000	7,250	7,450	9,850	14,300	15,000	15,050	14,900	14,700	14,700
		30 loaded	14,400	14,800	14,900	14,350	18,000	23,200	23,850	23,950	23,400	22,800	22,500
0	All	30 no load	13,700	14,000	13,550	13,000	16,600	21,900	22,800	21,850	21,150	19,400	18,300
		60 no load	9,700	10,000	9,950	9,800	12,750	18,000	19,150	18,900	18,250	17,750	17,250
		90 no load	6,300	7,000	7,250	7,450	9,850	14,300	15,650	15,900	16,050	16,150	16,500
		30 loaded	14,200	14,650	14,550	14,350	17,650	22,900	24,500	24,600	24,300	24,000	24,850
00	All	30 no load	13,700	14,000	13,550	13,000	16,600	21,900	23,850	23,700	23,100	22,500	20,900
		60 no load	9,700	10,000	9,950	9,800	12,750	18,000	20,000	20,050	19,900	20,200	19,900
		90 no load	6,300	7,000	7,250	7,450	9,850	14,300	16,350	17,000	17,350	18,300	18,700
		30 loaded	14,200	14,350	14,400	14,100	17,400	22,700	25,000	25,250	25,450	26,000	26,250
0000	All	30 no load	13,700	14,000	13,550	13,000	16,600	21,900	25,700	25,150	25,250	25,000	25,600
		60 no load	9,700	10,000	9,950	9,800	12,750	18,000	21,550	21,400	21,700	22,400	23,500
		90 no load	6,300	7,000	7,250	7,450	9,850	14,300	17,850	18,150	18,850	20,000	21,850
		30 loaded	14,000	14,300	14,100	13,700	17,150	22,400	25,800	26,350	26,500	27,300	28,550

Table 42.—Stresses in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths Corresponding to Recommended Sags of Table 36

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°*F.*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*
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	--------	--------	--------	--------
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	--------	--------	--------	--------
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	--------	--------	--------	--------
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	--------	--------	--------
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, [illegible]00	27, 400	28, 900	30, 700	31, 700	--------	--------
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
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
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
00	All	30 no load	8, 450	3, 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	15, 300	17, 100	17, 700	20, 250	22, 550	24, 200	25, 100
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

Table 42.—Stresses in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths Corresponding to Recommended Sags of Table 36—Continued

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°*F.*	*Lbs./in.*^{2}	*Lbs./in.*^{2}	*Lbs./in.*^{2}	*Lbs./in.*^{2}	*Lbs./in.*^{2}	*Lbs./in.*^{2}	*Lbs./in.*^{2}
8	C	30 no load	7,600	7,600	6,850	--------	--------	--------	--------
		60 no load	5,800	6,200	5,900	--------	--------	--------	--------
		90 no load	4,700	5,250	5,300	--------	--------	--------	--------
		15 loaded	25,500	31,000	30,050	--------	--------	--------	--------
6	A	30 no load	7,200	7,200	6,500	--------	--------	--------	--------
		60 no load	5,500	5,850	5,600	--------	--------	--------	--------
		90 no load	4,500	4,950	5,000	--------	--------	--------	--------
		15 loaded	20,400	22,400	23,200	--------	--------	--------	--------
6	B	30 no load	9,500	9,200	8,300	8,250	--------	--------	--------
		60 no load	6,850	7,150	6,850	6,950	--------	--------	--------
		90 no load	5,250	5,850	5,800	6,200	--------	--------	--------
		15 loaded	21,850	24,000	25,350	26,800	--------	--------	--------
6	C	30 no load	11,350	11,350	10,500	10,150	--------	--------	--------
		60 no load	8,250	8,500	8,300	8,400	--------	--------	--------
		90 no load	6,050	6,650	6,900	7,150	--------	--------	--------
		15 loaded	23,200	25,500	27,250	28,800	--------	--------	--------
4	All	30 no load	10,700	10,400	9,700	8,800	9,150	--------	--------
		60 no load	7,500	7,800	7,700	7,600	7,700	--------	--------
		90 no load	5,500	6,150	6,350	6,500	6,750	--------	--------
		15 loaded	19,000	20,900	21,900	22,850	24,050	--------	--------
2	All	30 no load	10,700	10,400	9,700	10,100	11,500	10,750	9,900
		60 no load	7,500	7,800	7,650	8,500	9,400	9,350	8,950
		90 no load	5,500	6,150	6,350	6,800	7,900	8,250	8,200
		15 loaded	16,700	17,750	18,200	19,750	21,650	22,800	22,750
1	All	30 no load	10,150	10,250	9,400	11,350	12,400	13,650	12,600
		60 no load	7,200	7,500	7,400	8,850	9,950	11,500	10,850
		90 no load	5,250	5,900	6,000	7,300	8,200	9,750	9,600
		15 loaded	15,500	16,500	16,700	18,800	20,800	23,600	23,600
0	All	30 no load	10,500	10,250	9,500	11,400	13,400	15,250	14,300
		60 no load	7,300	7,600	7,500	8,500	10,800	12,700	12,250
		90 no load	5,300	5,850	6,100	7,300	8,850	10,600	10,750
		15 loaded	14,850	15,600	15,600	18,300	20,200	23,250	23,300
00	All	30 no load	10,150	10,250	9,400	11,550	13,800	16,500	15,900
		60 no load	7,200	7,500	7,400	9,150	11,050	13,500	13,450
		90 no load	5,250	5,900	6,000	7,500	9,100	11,300	11,650
		15 loaded	14,300	14,750	14,500	16,900	19,350	22,750	23,200
0000	All	30 no load	10,100	9,900	9,150	11,700	14,550	18,300	18,800
		60 no load	6,950	7,150	7,150	9,250	11,450	14,850	15,500
		90 no load	5,050	5,550	5,800	7,450	9,250	12,100	13,250
		15 loaded	13,150	13,450	13,100	15,800	18,900	22,700	23,900

Table 42.—Stresses in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths Corresponding to Recommended Sags of Table 36—Continued

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
8	C	30 no load	9,950	9,500	8,750	8,750	--------	--------	--------
		60 no load	7,200	7,500	7,200	7,400	--------	--------	--------
		90 no load	5,650	6,150	6,150	6,500	--------	--------	--------
		30 loaded	17,400	19,000	19,750	20,750	--------	--------	--------
6	A	30 no load	9,500	9,200	8,300	8,250	--------	--------	--------
		60 no load	6,800	7,200	6,850	7,000	--------	--------	--------
		90 no load	5,250	5,800	5,800	6,200	--------	--------	--------
		30 loaded	15,100	16,150	16,350	17,450	--------	--------	--------
6	B	30 no load	11,950	11,250	10,550	10,200	10,150	--------	--------
		60 no load	8,200	8,500	8,400	8,350	8,600	--------	--------
		90 no load	6,350	6,700	6,900	7,100	7,500	--------	--------
		30 loaded	16,450	17,600	18,650	19,350	20,300	--------	--------
6	C	30 no load	14,200	14,200	13,200	13,050	12,450	--------	--------
		60 no load	10,300	10,650	10,200	10,450	10,250	--------	--------
		90 no load	7,450	8,100	8,200	8,650	8,700	--------	--------
		30 loaded	18,350	19,950	20,500	21,500	22,050	--------	--------
4	All	30 no load	13,200	13,050	12,000	11,850	11,500	--------	--------
		60 no load	9,400	9,750	9,350	9,500	9,450	--------	--------
		90 no load	6,000	7,300	6,850	7,750	8,000	--------	--------
		30 loaded	16,300	17,250	17,500	18,450	18,900	--------	--------
2	All	30 no load	13,200	13,050	12,000	13,200	14,250	16,700	15,100
		60 no load	9,400	9,750	9,350	10,300	11,450	13,800	12,950
		90 no load	6,600	7,300	6,850	8,300	9,350	11,550	11,250
		30 loaded	14,800	15,600	15,500	17,150	18,500	21,700	21,200
1	All	30 no load	12,800	12,800	12,000	13,600	15,300	17,550	17,100
		60 no load	9,100	9,450	9,050	10,600	12,000	14,550	14,450
		90 no load	6,300	7,000	7,150	8,500	9,750	12,100	12,250
		30 loaded	14,000	14,600	14,400	16,400	18,000	21,300	21,650
0	All	30 no load	12,950	12,800	11,900	13,550	16,000	18,750	19,550
		60 no load	9,200	9,500	9,050	10,700	12,750	15,250	16,400
		90 no load	6,450	7,100	7,150	8,500	10,300	12,700	14,000
		30 loaded	14,050	14,400	14,100	16,000	18,450	21,250	22,600
00	All	30 no load	12,800	12,800	11,750	13,900	16,350	19,500	20,700
		60 no load	9,100	9,450	9,000	10,950	13,000	15,900	17,300
		90 no load	6,300	7,000	7,050	8,650	10,400	12,950	14,750
		30 loaded	13,350	13,850	13,350	15,650	18,050	21,550	22,900
0000	All	30 no load	12,850	12,500	11,550	14,500	16,650	21,050	23,000
		60 no load	8,650	9,050	8,700	11,100	13,000	17,250	19,300
		90 no load	6,250	6,700	6,850	8,700	10,400	14,100	16,150
		30 loaded	13,000	13,350	12,350	15,150	17,600	22,250	24,300

Table 43.—Stresses in Soft-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 37

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 feet.	125 feet.	150 feet.	175 feet.	200 feet.
		° F.	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
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		
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		
4	B and 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		
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	
2	B and 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
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
1	B and 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
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
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
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

Table 43.—Stresses in Soft-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 37—Continued

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—					
			100 feet	125 feet	150 feet	175 feet	200 feet	250 feet
		°F	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*
6	C	30 no load	5,750	5,850	5,150			
		60 no load	4,600	4,800	4,650			
		90 no load	3,900	4,250	4,250			
		15 loaded	18,750	20,400	21,200			
4	All	30 no load	6,650	6,700	6,000	5,250		
		60 no load	5,050	5,350	5,150	4,800		
		90 no load	4,100	4,550	4,600	4,350		
		15 loaded	16,300	17,850	18,000	17,800		
2	All	30 no load	8,700	8,550	7,500	7,500	7,000	
		60 no load	6,250	6,500	6,250	6,400	6,250	
		90 no load	4,800	5,300	5,300	5,650	5,700	
		15 loaded	15,300	16,300	16,550	17,150	16,900	
1	All	30 no load	8,550	8,200	8,200	8,000	8,000	8,500
		60 no load	6,000	6,250	6,600	6,750	6,850	7,550
		90 no load	4,650	5,000	5,550	5,750	6,100	6,850
		15 loaded	14,000	14,800	16,200	16,200	16,750	18,250
0	All	30 no load	8,600	8,350	8,650	8,800	8,900	9,750
		60 no load	6,150	6,350	6,800	7,250	7,500	8,500
		90 no load	4,700	5,150	5,700	6,150	6,500	7,550
		15 loaded	13,350	13,800	14,850	15,400	16,000	17,800
00	All	30 no load	8,500	8,200	8,550	9,050	9,750	10,900
		60 no load	6,000	6,250	6,750	7,350	8,000	9,400
		90 no load	4,600	5,000	5,650	6,250	6,850	8,200
		15 loaded	12,350	13,000	13,600	14,450	15,700	17,800
0000	All	30 no load	8,150	8,100	8,300	8,700	9,300	10,550
		60 no load	5,800	6,100	6,550	7,100	7,700	9,050
		90 no load	4,400	4,850	5,450	6,000	6,550	7,900
		15 loaded	11,400	11,550	12,150	12,700	13,000	14,900

Table 43.—Stresses in Soft-Drawn Covered Copper Wire for Different Span Lengths Corresponding to the Recommended Sags of Table 37—Continued

LIGHT LOADING DISTRICTS

Size A.W.G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—					
			100 feet	125 feet	150 feet	175 feet	200 feet	250 feet
		°F.	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}
6	A	30 no load	5,750	5,700	5,150			
		60 no load	4,600	4,800	4,700			
		90 no load	3,850	4,250	4,300			
		30 loaded	12,000	12,300	13,000			
6	B and C	30 no load	7,250	7,300	6,450			
		60 no load	5,500	5,900	5,650			
		90 no load	4,450	5,000	5,000			
		30 loaded	13,600	14,600	14,600			
4	All	30 no load	8,750	8,500	8,400	8,650	8,400	
		60 no load	6,250	6,600	6,800	7,150	7,150	
		90 no load	4,700	5,300	5,700	6,250	6,350	
		30 loaded	13,100	13,700	14,400	15,500	15,800	
2	All	30 no load	10,700	10,500	10,350	10,500	9,950	11,400
		60 no load	7,500	7,800	7,950	8,500	8,350	9,750
		90 no load	5,500	6,050	6,500	7,000	7,150	8,500
		30 loaded	12,950	13,500	14,150	14,750	15,000	17,200
1	All	30 no load	10,450	10,300	10,700	11,300	12,000	12,900
		60 no load	7,250	7,500	8,100	8,850	9,600	10,750
		90 no load	5,250	5,900	6,500	7,300	8,000	9,250
		30 loaded	12,050	12,600	13,600	14,450	15,700	17,400
0	All	30 no load	10,400	10,250	10,700	11,350	12,000	13,100
		60 no load	7,300	7,600	8,300	9,000	9,750	10,900
		90 no load	5,250	5,900	6,600	7,350	8,100	9,400
		30 loaded	11,850	12,200	13,000	13,850	15,000	16,400
00	All	30 no load	10,400	10,200	10,650	11,200	11,900	12,750
		60 no load	7,250	7,500	8,050	8,800	9,600	10,650
		90 no load	5,250	5,850	6,500	7,250	8,000	9,200
		30 loaded	11,200	11,500	12,300	13,000	14,000	15,450
0000	All	30 no load	10,100	9,850	10,150	10,750	11,450	12,350
		60 no load	6,950	7,200	7,800	8,450	9,200	10,250
		90 no load	5,050	5,600	6,250	6,950	5,650	8,850
		30 loaded	10,500	10,900	11,350	12,100	13,000	14,150

Appendix B.—MINIMUM PERMISSIBLE SAGS FOR LINE CONDUCTORS OF GRADES A, B, AND C, AND CORRESPONDING TENSIONS

Sags of line conductors of different materials at 30, 60, and 90° F. have been computed, such that when loaded according to the loading specification for the district, the resulting tension in the conductor will equal 50 per cent of its ultimate strength for grades A and B, and 60 per cent for grade C (see rule 261, F, 4).

Tables 44 to 46 present values of the sag in the conductor for various spans for hard-drawn and medium copper; Table 47 (pp. 220 to 222) for soft copper; Tables 48 to 53 (pp. 223 to 235) for three grades of steel; Tables 54 and 55 (pp. 236 to 238) for copper-covered steel designated as standard grade; Table 56 (pp. 239 to 241) for aluminum; and Table 57 (pp. 242 to 244) for aluminum cable with steel core. Tables 58 to 71 (pp. 245 to 278) give the corresponding stringing tensions in the various conductors.

The properties of the various conductors involved in the computation of sags and tensions are given in Appendix D. These sags and tensions are not applicable to conductor materials having properties which differ considerably from the values on which the tables are based. When such materials are used, the sags and tensions should be based upon the actual properties of the material concerned.

Table 44.—Sags for Medium and Hard-Drawn Bare Solid Copper Wire

HEAVY LOADING DISTRICT

[The sags being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	4.4	15.6	36.5	------	------	------	------	------	------
		60	6.5	20.4	40.7	------	------	------	------	------	------
		90	9.7	24.6	44.5	------	------	------	------	------	------
6	A and B	30	4.4	12.3	27.7	------	------	------	------	------	------
		60	6.5	16.9	32.8	------	------	------	------	------	------
		90	9.7	21.6	37.1	------	------	------	------	------	------
	C	30	2.6	5.1	10.6	22.7	------	------	------	------	------
		60	3.1	6.8	14.8	28.6	------	------	------	------	------
		90	4.1	9.4	19.8	34.2	------	------	------	------	------
4	A and B	30	3.0	5.5	10.6	19.3	33.1	66.6	109	------	------
		60	3.8	7.7	14.6	25.2	39.1	72.3	115	------	------
		90	5.3	10.8	19.6	31.5	45.1	78.4	121	------	------
	C	30	2.2	3.6	6.1	9.4	15.1	37.2	71.0	------	------
		60	2.6	4.5	7.2	11.9	19.4	44.7	79.0	------	------
		90	3.1	5.7	9.5	16.2	25.2	52.2	86.0	------	------
2	A and B	30	2.9	4.8	7.6	11.8	17.8	38.4	67.0	142	238
		60	3.5	6.2	9.7	15.5	23.0	45.6	74.5	150	252
		90	4.8	8.3	13.3	20.6	29.5	53.1	82.4	158	260
	C	30	2.1	3.4	5.4	7.6	11.0	21.0	38.9	97	172
		60	2.6	4.2	6.5	9.5	13.4	26.4	46.8	106	191
		90	3.1	5.3	7.9	11.8	17.3	33.3	55.4	117	202
1	A and B	30	2.9	4.6	7.0	10.5	15.4	30.6	53.6	118	203
		60	3.5	6.0	9.0	13.6	20.1	37.8	62.6	127	212
		90	4.8	7.9	12.4	18.1	25.4	45.6	70.6	135	220
	C	30	2.2	3.3	5.0	7.6	10.1	18.3	31.7	77.8	148
		60	2.6	3.9	6.5	9.0	12.5	22.8	38.9	88.4	157
		90	3.2	5.2	7.9	11.3	15.8	28.8	46.8	98.4	168
0	A and B	30	2.8	4.5	6.8	10.1	14.1	26.4	45.3	99.8	173
		60	3.5	6.0	9.0	13.0	18.2	33.6	53.2	109	184
		90	4.8	7.9	12.2	17.2	23.7	40.2	61.9	119	193
	C	30	2.2	3.3	5.2	7.6	10.1	17.4	28.4	65.8	122
		60	2.6	4.2	6.5	8.8	12.5	21.6	34.9	75.8	135
		90	3.4	5.3	7.9	11.6	15.6	26.7	42.5	86.4	146
00	A and B	30	2.9	4.8	6.8	9.6	13.7	24.6	40.0	86.9	152
		60	3.7	6.0	9.0	12.6	17.7	30.6	47.9	97.0	163
		90	5.0	8.1	11.9	16.8	23.0	37.5	56.5	107	171
	C	30	2.3	3.6	5.2	7.6	10.1	16.8	26.6	58.1	106
		60	2.8	4.3	6.3	9.0	12.2	21.0	32.4	68.2	117
		90	3.4	5.4	8.1	11.3	15.1	26.1	39.6	77.8	129
0000	A and B	30	3.1	5.0	7.2	10.1	13.2	22.8	35.7	71.1	121
		60	4.1	6.5	9.4	13.0	17.3	28.8	43.2	81.6	133
		90	5.5	8.7	12.8	17.0	22.3	35.7	51.8	91.2	144
	C	30	2.5	3.9	5.6	7.8	10.1	16.8	25.2	50.9	88.8
		60	3.0	4.8	6.8	9.5	12.7	20.4	30.6	60.0	101
		90	3.8	6.2	8.6	11.8	15.9	26.1	37.8	69.2	112

Table 44.—Sags for Medium and Hard-Drawn Bare Solid Copper Wire—Continued

MEDIUM LOADING DISTRICT

[The sags being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—										
			100	125	150	175	200	250	300	400	500	700	1,000
		°F.											
8	B	30	2.8	5.3	10.1	-----	-----	-----	-----	-----	-----	-----	-----
		60	3.4	6.9	13.7	-----	-----	-----	-----	-----	-----	-----	-----
		90	4.4	9.4	18.7	-----	-----	-----	-----	-----	-----	-----	-----
	C	30	2.0	3.3	5.6	-----	-----	-----	-----	-----	-----	-----	-----
		60	2.3	3.9	6.7	-----	-----	-----	-----	-----	-----	-----	-----
		90	2.8	4.9	8.8	-----	-----	-----	-----	-----	-----	-----	-----
6	A and B	30	2.4	3.9	6.5	10.1	-----	-----	-----	-----	-----	-----	-----
		60	2.9	5.1	8.1	13.0	-----	-----	-----	-----	-----	-----	-----
		90	3.7	6.6	10.8	17.2	-----	-----	-----	-----	-----	-----	-----
	C	30	1.9	3.1	4.7	6.7	-----	-----	-----	-----	-----	-----	-----
		60	2.2	3.4	5.4	8.0	-----	-----	-----	-----	-----	-----	-----
		90	2.6	4.3	6.5	9.7	-----	-----	-----	-----	-----	-----	-----
4	A and B	30	2.3	3.3	5.4	8.0	11.0	20.4	36.0	86.4	-----	-----	-----
		60	2.8	4.3	6.7	9.6	13.9	25.8	43.9	96.5	-----	-----	-----
		90	3.4	5.5	8.6	12.4	17.8	32.1	52.2	106.0	-----	-----	-----
	C	30	1.9	3.0	4.5	6.1	8.2	13.5	21.9	53.8	-----	-----	-----
		60	2.2	3.3	5.0	6.9	9.4	16.2	26.6	63.4	-----	-----	-----
		90	2.6	3.9	5.9	8.2	11.3	19.5	32.4	74.4	-----	-----	-----
2	A and B	30	2.3	3.6	5.4	7.6	10.1	17.1	27.7	61.0	112.0	259	-----
		60	2.9	4.2	6.7	9.2	12.5	21.6	33.8	71.0	125.0	273	-----
		90	3.4	5.5	8.3	11.8	15.8	26.7	42.1	81.6	136.0	284	-----
	C	30	1.9	3.0	4.5	6.1	8.2	12.6	19.8	41.3	75.0	189	-----
		60	2.2	3.5	5.0	6.9	9.1	15.3	23.0	49.0	86.4	204	-----
		90	2.6	4.0	5.9	8.4	11.3	18.3	28.1	57.1	98.4	218	-----
1	A and B	30	2.4	3.6	5.4	7.6	10.1	17.1	25.9	54.7	99.1	227	-----
		60	2.9	4.5	6.7	9.2	12.5	21.3	31.7	64.3	111.0	242	-----
		90	3.6	5.7	8.5	11.8	15.9	26.1	38.9	74.9	122.0	255	-----
	C	30	2.0	3.1	4.3	5.7	8.2	13.2	19.4	38.4	68.4	166	-----
		60	2.3	3.4	5.0	7.1	9.1	15.0	23.0	45.1	78.6	181	-----
		90	2.8	4.2	6.3	8.4	11.3	18.6	27.3	53.2	90.0	196	-----
0	A and B	30	2.5	3.7	5.6	7.6	10.3	16.8	25.2	51.8	90.0	205	-----
		60	3.0	4.6	6.8	9.4	12.7	21.0	31.0	61.4	103.0	220	-----
		90	3.8	6.0	8.8	12.0	15.6	26.1	37.8	71.0	114.0	233	-----
	C	30	2.0	3.1	4.5	6.3	8.4	13.2	19.4	37.4	64.8	151	-----
		60	2.4	3.6	5.2	7.3	9.6	15.6	23.0	44.2	74.4	165	-----
		90	2.9	4.5	6.5	8.8	11.5	19.2	27.4	51.8	86.4	181	-----
00	A and B	30	2.6	3.9	5.8	7.8	10.6	17.1	25.2	50.4	85.2	190	422
		60	3.1	4.9	6.8	9.7	13.0	20.7	31.0	59.5	97.2	204	439
		90	4.1	6.3	9.0	12.2	16.3	26.4	37.8	69.1	109.0	218	455
	C	30	2.2	3.3	4.7	6.3	8.4	13.5	19.8	37.4	62.4	141	329
		60	2.5	3.7	5.4	7.6	10.1	15.9	23.4	44.6	72.0	154	346
		90	3.0	4.6	6.7	9.0	12.0	19.2	28.1	51.8	82.8	171	366
0000	A and B	30	2.6	4.2	6.1	8.2	11.0	17.4	25.9	49.6	81.6	171	374
		60	3.2	5.4	7.6	10.5	13.4	22.2	31.7	57.6	93.0	185	392
		90	4.4	6.9	10.1	13.4	17.5	27.0	38.9	67.6	104.0	201	410
	C	30	2.2	3.4	4.9	6.9	8.9	13.8	20.5	37.4	61.8	132	299
		60	2.8	4.0	5.8	8.0	10.8	16.8	24.1	44.6	70.8	146	317
		90	3.2	5.3	7.4	10.1	13.2	20.7	29.9	51.8	81.6	161	337

Table 44.—Sags for Medium and Hard-Drawn Bare Solid Copper Wire—Continued

LIGHT LOADING DISTRICT

[The sags being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—										
			100	125	150	175	200	250	300	400	500	700	1,000
		° *F.*											
8	B	30	1.9	3.0	4.5	------	------	------	------	------	------	------	------
		60	2.3	3.6	5.0	------	------	------	------	------	------	------	------
		90	2.6	4.2	6.1	------	------	------	------	------	------	------	------
	C	30	1.6	2.5	3.6	5.0	------	------	------	------	------	------	------
		60	1.9	2.8	4.3	5.7	------	------	------	------	------	------	------
		90	2.2	3.3	4.8	6.3	------	------	------	------	------	------	------
6	A and B	30	2.0	3.1	4.7	6.1	8.2	------	------	------	------	------	------
		60	2.3	3.4	5.2	7.1	9.4	------	------	------	------	------	------
		90	2.8	4.3	6.3	8.4	11.5	------	------	------	------	------	------
	C	30	1.7	2.7	4.0	5.0	6.7	------	------	------	------	------	------
		60	2.0	3.0	4.5	5.9	7.7	------	------	------	------	------	------
		90	2.2	3.4	4.9	6.7	8.6	------	------	------	------	------	------
4	A and B	30	2.0	3.1	4.7	6.3	8.2	12.9	18.7	35.5	58.2	------	------
		60	2.4	3.6	5.2	7.1	9.4	15.0	22.0	41.3	67.2	------	------
		90	2.9	4.3	6.5	8.8	11.5	18.0	26.6	49.0	78.0	------	------
	C	30	1.7	2.8	3.8	5.0	6.7	10.8	15.1	27.8	45.0	------	------
		60	1.9	3.0	4.5	6.1	7.9	12.0	17.3	31.7	51.0	------	------
		90	2.3	3.4	5.0	6.7	8.9	13.8	20.2	36.5	58.8	------	------
2	A and B	30	2.2	3.3	4.9	6.3	8.4	13.2	19.4	35.5	58.2	124.0	------
		60	2.5	3.6	5.4	7.6	10.1	15.6	22.3	41.3	67.2	138.0	------
		90	3.0	4.6	6.5	9.0	12.0	18.9	27.0	49.5	76.8	153.0	------
	C	30	1.7	2.7	4.3	5.5	7.0	10.8	15.8	28.8	45.6	97.4	------
		60	2.0	3.3	4.7	6.1	8.2	12.6	18.0	33.1	52.2	107.0	------
		90	2.4	3.4	5.2	7.1	9.1	15.3	20.9	37.9	60.0	122.0	------
1	A and B	30	2.2	3.3	4.9	6.5	8.6	13.5	19.8	36.5	58.2	124.0	276
		60	2.6	3.9	5.8	7.6	10.1	16.2	23.0	42.2	67.2	139.0	294
		90	3.1	4.8	6.8	9.5	12.5	19.5	27.7	49.9	78.0	154.0	315
	C	30	1.8	2.7	4.1	5.5	7.2	11.1	15.8	29.3	46.2	97.4	216
		60	2.2	3.3	4.7	6.3	8.2	12.9	18.7	33.6	53.4	109.0	234
		90	2.5	3.8	5.4	7.4	9.6	15.0	22.0	39.4	61.2	122.0	252
0	A and B	30	2.2	3.3	5.0	6.7	8.6	13.8	20.2	36.9	60.0	124.0	274
		60	2.6	4.0	5.9	8.0	10.6	16.8	23.7	43.2	69.0	138.0	293
		90	3.2	5.1	7.2	9.9	13.0	20.4	28.8	50.9	79.2	154.0	312
	C	30	1.9	3.0	4.3	5.7	7.4	11.4	16.6	29.7	47.4	97.5	216
		60	2.2	3.3	4.9	6.5	8.6	13.5	19.1	34.5	54.6	109.0	234
		90	2.5	3.9	5.8	7.8	10.1	15.6	22.3	40.8	63.0	123.0	252
00	A and B	30	2.3	3.4	5.0	6.9	9.1	14.4	20.9	37.4	60.0	124.0	273
		60	2.8	4.4	6.3	8.4	11.0	16.8	24.5	44.2	69.6	139.0	291
		90	3.4	5.4	7.7	10.3	13.4	21.0	30.2	51.8	80.4	153.0	312
	C	30	1.9	3.2	4.5	5.9	7.7	12.0	17.3	30.7	48.6	99.2	216
		60	2.2	3.4	5.0	6.7	8.9	13.8	19.4	36.0	55.8	112.0	234
		90	2.6	4.1	5.9	8.0	10.6	16.2	23.0	41.3	64.2	125.0	252
0000	A and B	30	2.5	3.8	5.4	7.4	9.8	15.3	21.9	39.8	63.6	129.0	274
		60	3.0	4.6	6.5	8.8	11.8	18.6	26.3	46.1	73.2	144.0	293
		90	3.8	5.9	8.5	11.3	14.9	23.2	32.0	55.7	84.0	158.0	312
	C	30	2.1	3.3	4.7	6.3	8.2	12.6	18.0	32.6	51.6	104.0	222
		60	2.5	3.6	5.4	7.4	9.4	15.3	20.9	37.4	59.4	116.0	241
		90	2.9	4.5	6.5	8.8	11.5	17.7	25.2	44.6	69.0	131.0	259

Table 45.—Sags for Medium and Hard-Drawn Bare Stranded Copper Wire

HEAVY LOADING DISTRICT

[The sags being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Tem-pera-ture	Sags (inches) for span lengths (feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	2.9	5.4	10.4	32.6	67.2	------	------	------	------
		60	3.6	7.2	14.4	39.4	72.6	------	------	------	------
		90	5.0	10.2	19.4	45.1	79.2	------	------	------	------
	C	30	2.2	3.6	5.7	14.9	36.0	------	------	------	------
		60	2.6	4.2	7.2	19.2	43.8	------	------	------	------
		90	3.1	5.4	9.4	25.0	51.6	------	------	------	------
2	A and B	30	2.6	4.5	7.2	16.8	36.0	99.1	240	------	------
		60	3.4	5.7	9.4	22.1	43.8	107.0	248	------	------
		90	4.3	7.8	13.0	28.3	51.6	115.0	256	------	------
	C	30	2.2	3.3	5.0	10.1	19.8	62.2	176	------	------
		60	2.4	3.9	5.7	12.5	25.2	72.2	186	------	------
		90	2.9	4.8	7.5	15.8	31.2	81.5	196	------	------
1	A and B	30	2.6	4.5	6.8	14.9	31.2	82.3	203	438	------
		60	3.4	5.7	9.0	19.7	36.6	90.7	212	447	------
		90	4.6	7.5	11.9	25.0	44.4	100.0	221	454	------
	C	30	2.2	3.3	5.0	10.1	17.4	51.2	146	338	761
		60	2.6	3.9	6.1	12.0	23.4	59.6	157	348	770
		90	3.1	5.1	7.9	15.4	27.6	69.7	167	358	780
0	A and B	30	2.6	4.2	6.5	12.5	23.4	63.0	161	349	787
		60	3.1	5.4	7.9	15.8	29.4	72.2	172	368	797
		90	4.3	6.9	10.8	21.1	37.2	82.3	181	378	806
	C	30	2.2	3.3	5.0	9.1	15.6	38.6	113	270	624
		60	2.4	3.9	5.8	11.0	19.8	47.0	119	282	634
		90	2.9	4.8	6.8	13.4	23.4	50.4	137	296	648
00	A and B	30	2.6	4.2	6.5	12.5	21.6	54.6	140	307	682
		60	3.4	5.4	7.9	15.4	27.0	63.8	144	319	691
		90	4.3	7.2	10.4	20.2	33.6	73.1	149	331	698
	C	30	2.2	3.3	4.7	9.1	15.0	36.1	96	232	535
		60	2.6	3.9	5.8	10.6	18.0	42.8	107	245	547
		90	3.1	4.8	7.2	13.0	22.2	51.2	120	259	562
0000	A and B	30	2.6	4.2	6.1	11.5	18.6	42.0	102	222	506
		60	3.1	5.1	7.6	13.9	22.8	50.4	114	244	523
		90	4.3	6.9	9.7	18.2	28.8	58.8	126	257	535
	C	30	2.2	3.3	4.7	8.6	13.8	30.2	73	160	396
		60	2.6	3.9	5.7	10.0	16.8	36.1	84	176	413
		90	3.1	4.8	6.8	12.5	21.0	43.7	96	188	432

Table 45.—Sags for Medium and Hard-Drawn Bare Stranded Copper Wire—Continued.

MEDIUM LOADING DISTRICT

[The sags being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	2.2	3.6	5.4	11.0	19.8	60.5	------	------	------
		60	2.6	4.2	6.5	13.4	25.8	69.7	------	------	------
		90	3.1	5.4	8.3	16.8	29.4	79.8	------	------	------
	C	30	1.9	3.0	4.3	8.2	13.2	36.1	------	------	------
		60	2.2	3.3	5.0	9.1	15.6	42.8	------	------	------
		90	2.4	3.9	5.7	11.0	19.8	49.6	------	------	------
2	A and B	30	2.4	3.6	5.0	10.1	16.8	41.2	112	260	590
		60	2.6	4.2	6.1	12.0	20.4	49.6	124	274	602
		90	3.4	5.4	7.9	15.4	25.2	58.8	133	286	614
	C	30	1.9	3.0	4.3	7.7	12.6	27.7	74.4	188	458
		60	2.2	3.3	5.0	9.1	14.4	33.6	85.2	203	473
		90	2.6	3.9	5.7	11.0	17.4	39.5	97.2	217	487
1	A and B	30	2.4	3.6	5.4	10.1	16.8	37.8	99.6	230	521
		60	2.9	4.5	6.5	12.0	19.8	45.4	112	244	538
		90	3.4	5.7	7.9	14.9	25.2	53.8	124	257	550
	C	30	1.9	3.0	4.3	7.7	12.6	27.7	68.4	166	403
		60	2.2	3.3	5.0	9.1	15.0	31.9	79.2	183	420
		90	2.6	4.2	6.1	11.0	17.4	38.6	90.0	197	437
0	A and B	30	2.4	3.6	5.0	9.6	15.6	34.4	85.2	191	446
		60	2.9	4.2	6.5	11.5	18.6	41.2	96.0	210	461
		90	3.4	5.4	7.9	14.4	23.4	49.6	109	225	475
	C	30	1.9	3.0	4.3	7.7	12.0	25.2	60.0	141	343
		60	2.2	3.3	5.0	8.6	14.4	30.2	69.6	156	360
		90	2.6	3.9	5.8	10.6	16.8	35.3	79.2	171	379
00	A and B	30	2.4	3.6	5.4	9.6	15.6	33.6	79.2	176	396
		60	2.9	4.5	6.5	11.5	18.6	40.3	91.2	191	415
		90	3.6	5.7	7.9	14.9	22.8	47.0	102	207	430
	C	30	1.9	3.0	4.3	7.7	12.6	26.0	58.8	133	305
		60	2.4	3.3	5.0	9.1	14.4	30.2	67.2	146	324
		90	2.9	4.2	6.1	11.0	16.8	39.5	76.8	161	343
0000	A and B	30	2.4	3.6	5.4	9.6	15.0	31.1	69.6	149	331
		60	2.9	4.5	6.5	11.5	18.0	37.8	80.4	173	350
		90	3.6	5.7	8.3	14.4	22.2	43.7	91.2	180	367
	C	30	1.9	3.0	4.3	7.7	12.0	25.2	52.8	114	259
		60	2.4	3.6	5.0	9.1	14.4	28.6	62.4	128	276
		90	2.6	4.2	6.1	10.6	16.8	34.4	72.0	143	298

Table 45.—Sags for Medium and Hard-Drawn Bare Stranded Copper Wire—Continued.

LIGHT LOADING DISTRICT

[The sags being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	1.9	3.0	4.3	7.7	12.0	25.2	61.2	------	------
		60	2.4	3.6	5.0	9.1	14.4	30.2	70.8	------	------
		90	2.9	4.2	6.1	11.0	17.4	37.0	81.6	------	------
	C	30	1.7	2.4	3.6	6.7	10.2	21.0	45.6	------	------
		60	1.9	3.0	4.3	7.2	11.4	23.5	52.8	------	------
		90	2.2	3.3	4.7	8.6	13.8	27.7	60.0	------	------
2	A and B	30	2.2	3.3	4.7	8.2	12.6	26.9	58.8	129	------
		60	2.4	3.6	5.4	9.6	15.0	30.2	67.2	143	------
		90	2.9	4.5	6.5	11.5	18.0	37.0	78.0	158	------
	C	30	1.7	2.4	4.0	6.7	10.2	21.0	45.6	99.1	------
		60	1.9	3.0	4.3	7.7	12.0	24.4	51.6	111	------
		90	2.4	3.6	5.0	9.1	13.8	27.7	60.0	124	------
1	A and B	30	2.2	3.3	4.7	8.2	13.2	26.9	46.8	128	290
		60	2.4	3.6	5.4	9.6	15.6	31.1	68.4	141	307
		90	2.9	4.8	6.8	12.0	19.2	38.6	78.0	156	326
	C	30	1.9	2.7	4.0	7.2	10.8	21.8	46.8	99.1	223
		60	2.2	3.0	4.3	8.2	12.6	25.2	54.0	111	242
		90	2.4	3.6	5.0	9.6	14.4	29.4	61.2	124	262
0	A and B	30	2.2	3.3	4.7	8.2	12.6	26.7	57.6	121	271
		60	2.4	3.6	5.4	9.6	15.0	30.2	66.0	134	290
		90	2.9	4.5	6.5	12.0	18.0	37.0	75.6	149	310
	C	30	1.7	2.7	4.0	6.7	10.8	21.8	45.6	95.8	211
		60	1.9	3.3	4.7	7.7	12.6	24.4	52.8	106	228
		90	2.4	3.6	5.4	9.1	14.4	28.6	60.0	119	247
00	A and B	30	2.2	3.3	4.7	8.2	13.2	26.9	57.6	102	264
		60	2.4	3.6	5.8	10.1	15.6	31.1	66.0	133	281
		90	3.1	4.8	6.8	12.0	19.2	37.8	76.8	148	302
	C	30	1.9	3.0	4.3	7.2	10.8	21.8	46.8	94.1	209
		60	2.2	3.3	4.7	8.2	12.6	25.2	52.8	106	226
		90	2.4	3.6	5.4	9.6	15.0	29.4	60.0	119	242
0000	A and B	30	2.2	3.3	4.7	8.6	13.2	26.9	56.4	116	247
		60	2.6	3.9	5.8	10.1	15.6	31.1	64.8	129	266
		90	3.1	4.8	6.8	12.5	19.2	37.0	74.4	143	286
	C	30	1.9	3.0	4.3	7.2	10.8	22.7	46.8	92.4	199
		60	2.2	3.3	4.7	8.2	12.6	25.2	52.8	104	216
		90	2.4	3.6	5.4	9.6	15.0	29.4	61.2	116	235

Table 46.—Sags for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire

HEAVY LOADING DISTRICT

[The sags being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	C	30	10.2	29.7	50.4	----	----	----	----
		60	13.3	31.5	53.6	----	----	----	----
		90	17.2	35.1	56.6	----	----	----	----
6	A and B	30	8.7	23.1	37.1	----	----	----	----
		60	12.2	26.6	44.7	----	----	----	----
		90	15.6	30.6	48.1	----	----	----	----
	C	30	4.1	9.7	22.5	38.9	----	----	----
		60	5.4	12.7	27.7	44.1	----	----	----
		90	7.2	16.9	32.0	48.5	----	----	----
4	A and B	30	4.4	9.6	18.4	32.8	48.7	----	----
		60	6.1	12.4	23.0	38.0	54.2	----	----
		90	8.2	16.6	28.1	42.9	58.8	----	----
	C	30	2.9	5.3	9.2	16.2	26.4	----	----
		60	3.7	6.6	11.5	20.2	32.6	----	----
		90	4.6	8.4	15.1	25.4	38.9	----	----
2	A and B	30	3.8	6.6	11.2	18.7	28.3	55.5	90.0
		60	5.0	8.7	14.8	23.1	34.1	62.4	97.2
		90	6.5	11.5	18.9	28.6	40.1	68.4	104
	C	30	3.0	4.8	7.4	11.3	16.3	33.3	60.2
		60	3.5	5.7	9.0	14.3	20.1	39.6	67.4
		90	4.3	7.1	11.5	17.2	25.0	46.2	75.6
1	A and B	30	3.6	6.1	9.7	15.5	22.6	44.4	73.4
		60	4.6	7.8	12.6	19.7	38.1	52.2	81.8
		90	6.2	10.8	16.7	24.6	34.1	58.2	88.2
	C	30	2.8	4.6	6.8	10.1	13.9	27.3	46.1
		60	3.2	5.5	8.5	12.2	17.7	33.6	55.1
		90	4.2	6.9	10.6	15.7	21.8	40.2	62.3
0	A and B	30	3.7	6.0	9.4	14.1	20.6	38.4	62.6
		60	4.8	7.8	12.1	17.8	25.4	45.0	70.6
		90	6.4	10.6	15.6	22.9	31.2	52.8	78.2
	C	30	2.8	4.6	6.8	9.9	13.7	24.6	41.0
		60	3.5	5.5	8.1	12.2	16.8	30.3	48.6
		90	4.4	6.7	10.1	14.9	20.9	35.7	55.8
00	A and B	30	3.6	6.0	9.0	13.2	18.5	33.6	54.0
		60	4.6	7.8	11.5	16.8	23.0	39.9	61.9
		90	6.1	10.5	15.1	21.4	28.5	46.8	70.9
	C	30	2.6	4.6	7.0	9.7	13.2	22.8	36.0
		60	3.2	5.5	8.3	11.8	16.1	27.6	43.6
		90	4.2	6.9	10.4	14.5	20.1	33.6	50.8
0000	A and B	30	3.7	6.0	9.0	12.6	17.5	28.8	45.0
		60	4.8	7.8	11.5	16.2	21.1	34.8	53.3
		90	6.6	10.5	15.1	20.4	27.1	42.0	61.2
	C	30	2.9	4.6	6.8	9.7	12.7	20.4	32.4
		60	3.6	5.7	8.5	11.8	15.6	25.5	38.9
		90	4.6	7.4	10.4	14.5	19.7	30.9	45.7

55862°—27——18

Table 46.—Sags for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire—Continued

MEDIUM LOADING DISTRICT

[The sags being such that when loaded at 15° F, the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	B	30	4.8	11.2	23.2				
		60	6.2	14.7	27.3				
		90	8.6	18.4	32.1				
	C	30	3.2	6.0	10.8				
		60	3.7	7.4	13.7				
		90	4.6	9.3	17.3				
6	A and B	30	3.6	6.6	11.5	19.7			
		60	4.4	8.3	14.8	24.4			
		90	5.8	10.8	19.1	29.6			
	C	30	2.8	4.6	7.2	11.1			
		60	3.1	5.4	8.6	13.6			
		90	3.6	6.6	10.6	16.8			
4	A and B	30	3.0	5.1	7.9	11.8	17.3		
		60	3.7	6.1	9.7	14.9	21.6		
		90	4.7	7.8	12.6	18.9	26.6		
	C	30	2.5	4.0	5.8	8.6	11.5		
		60	2.9	4.5	6.8	10.1	13.7		
		90	3.4	5.4	8.1	12.2	16.8		
2	A and B	30	3.0	4.8	7.2	10.7	14.4	25.8	41.8
		60	3.7	6.0	8.1	13.0	18.0	31.2	49.7
		90	4.7	7.6	11.2	16.4	22.1	37.5	56.9
	C	30	2.5	4.0	5.8	8.0	10.8	18.6	28.8
		60	2.9	4.5	6.7	9.2	12.7	21.0	33.8
		90	3.5	5.4	8.1	11.3	15.4	25.5	40.3
1	A and B	30	2.9	4.8	7.2	10.1	13.7	23.4	36.7
		60	3.6	5.8	8.6	12.2	16.8	28.5	43.9
		90	4.6	7.5	11.0	15.1	20.9	34.5	50.8
	C	30	2.5	4.0	5.8	7.8	10.3	17.4	26.6
		60	2.8	4.5	6.7	9.2	12.2	19.8	31.0
		90	3.4	5.4	7.9	10.9	14.9	24.3	36.7
0	A and B	30	3.1	4.9	7.2	10.1	13.7	23.4	34.5
		60	3.8	6.0	8.8	12.2	16.8	28.2	40.7
		90	4.9	7.8	11.2	15.5	20.9	34.2	49.0
	C	30	2.6	4.2	5.8	8.0	10.8	17.4	25.2
		60	3.0	4.8	6.8	9.2	12.7	20.4	29.5
		90	3.7	5.7	8.1	11.3	15.1	24.6	35.3
00	A and B	30	3.2	5.1	7.2	10.1	13.4	22.2	34.2
		60	4.0	6.0	9.0	12.6	16.6	26.7	40.3
		90	5.0	7.9	11.5	15.9	20.6	32.7	47.2
	C	30	2.5	4.1	5.8	8.2	10.6	17.1	25.9
		60	2.9	4.8	6.8	9.7	12.5	20.1	30.2
		90	3.6	5.7	8.3	10.8	15.4	24.3	35.6
0000	A and B	30	3.1	5.1	7.6	10.5	13.7	21.6	32.8
		60	4.1	6.5	9.4	12.6	16.8	26.4	39.2
		90	5.4	8.4	12.1	16.4	21.1	32.4	45.7
	C	30	2.6	4.2	6.1	8.4	10.8	16.8	25.9
		60	3.1	5.0	7.2	10.1	12.7	20.4	30.2
		90	3.9	6.2	9.0	12.2	15.8	24.6	36.0

Table 46.—Sags for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire—Continued

LIGHT LOADING DISTRICT

[The sags being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	B	30	3.1	5.1	7.7	--------	--------	--------	--------
		60	3.6	6.0	9.4	--------	--------	--------	--------
		90	4.4	7.5	11.2	--------	--------	--------	--------
	C	30	2.4	3.9	5.9	8.2	--------	--------	--------
		60	2.9	4.6	6.7	9.2	--------	--------	--------
		90	3.2	5.3	7.7	11.3	--------	--------	--------
6	A and B	30	2.8	4.6	6.8	9.7	13.2	--------	--------
		60	3.0	5.4	8.1	11.6	15.8	--------	--------
		90	3.8	6.5	9.9	14.1	19.2	--------	--------
	C	30	2.4	3.8	5.6	7.6	10.1	--------	--------
		60	2.8	4.3	6.5	8.8	11.5	--------	--------
		90	3.0	4.9	7.4	10.5	13.7	--------	--------
4	A and B	30	2.8	4.2	6.3	8.6	11.8	--------	--------
		60	3.1	4.8	7.0	10.1	13.7	--------	--------
		90	3.7	5.9	8.6	12.2	16.6	--------	--------
	C	30	2.4	3.6	5.0	7.1	9.1	--------	--------
		60	2.6	3.9	5.8	8.0	10.3	--------	--------
		90	2.9	4.5	6.5	9.0	12.5	--------	--------
2	A and B	30	2.8	4.3	6.1	8.4	11.8	18.3	27.3
		60	3.2	5.1	7.2	10.1	13.4	21.9	32.0
		90	4.1	6.2	8.6	12.2	16.8	25.8	37.8
	C	30	2.4	3.6	5.0	7.1	9.6	15.0	21.6
		60	2.6	4.2	5.8	8.0	10.6	16.8	24.5
		90	2.9	4.8	6.8	9.7	12.5	19.8	28.8
1	A and B	30	2.6	4.2	6.1	8.4	11.3	17.4	26.6
		60	2.9	4.9	7.2	10.1	13.2	21.0	31.3
		90	4.0	6.2	8.6	12.2	16.3	25.5	36.7
	C	30	2.3	3.8	5.0	7.1	9.1	14.4	20.9
		60	2.6	4.0	5.8	7.8	10.6	16.8	24.5
		90	3.0	4.8	6.8	9.2	12.5	19.2	28.4
0	A and B	30	2.8	4.5	6.3	9.0	11.5	18.0	27.3
		60	3.4	5.3	7.6	10.7	13.9	21.6	32.0
		90	4.2	6.6	9.4	12.8	16.8	26.4	37.4
	C	30	2.4	3.8	5.2	7.1	9.6	15.0	22.0
		60	2.8	4.3	6.1	8.4	11.0	17.1	25.2
		90	3.1	5.1	7.2	10.1	13.0	20.1	29.1
00	A and B	30	2.8	4.5	6.5	8.8	11.5	18.3	27.0
		60	3.5	5.4	7.9	10.1	13.4	21.6	31.3
		90	4.3	6.6	9.7	12.8	16.6	26.7	37.4
	C	30	2.4	5.9	5.4	7.1	9.6	15.0	21.6
		60	2.6	4.2	6.5	8.2	11.0	17.1	25.2
		90	3.2	5.1	7.4	10.1	13.2	20.4	29.5
0000	A and B	30	2.9	4.5	6.7	8.8	11.5	18.6	27.3
		60	3.5	5.4	7.9	10.9	14.4	22.2	32.4
		90	4.6	7.2	9.9	13.6	17.7	27.0	38.6
	C	30	2.6	3.9	5.6	7.6	9.6	15.3	22.7
		60	2.8	4.5	6.5	9.0	11.3	17.4	26.3
		90	3.5	5.4	7.9	10.5	13.4	21.0	31.0

Table 47.—Sags for T. B. W. P. Solid Soft Copper Wire

HEAVY LOADING DISTRICT

[The sags being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of—					
			100	125	150	175	200	250
		°F.						
6	C	30	29.1	50.2	76.9			
		60	31.4	52.8	78.9			
		90	33.6	55.2	81.0			
4	A and B	30	22.8	39.3	60.1			
		60	25.8	42.5	62.8			
		90	28.4	45.3	65.5			
	C	30	14.5	28.3	45.5			
		60	18.1	32.0	48.9			
		90	21.6	35.0	50.4			
2	A and B	30	12.4	22.9	37.1	53.4	72.8	
		60	16.1	27.3	41.2	58.0	76.3	
		90	19.7	30.9	45.0	61.4	80.6	
	C	30	7.2	14.2	25.1	38.7	55.0	
		60	10.1	18.6	30.2	43.9	59.3	
		90	14.0	23.1	34.7	48.3	63.8	
1	A and B	30	9.6	17.9	28.8	43.3	58.1	
		60	12.6	22.5	33.6	47.9	63.6	
		90	17.0	26.2	37.8	52.3	68.4	
	C	30	6.0	10.9	18.4	29.8	42.2	
		60	8.0	14.7	23.8	34.9	48.0	
		90	11.7	19.2	28.4	40.3	53.6	
0	A and B	30	7.8	14.4	23.6	35.3	48.2	
		60	11.3	18.9	28.3	40.5	53.3	
		90	15.0	23.1	33.1	45.0	57.2	
	C	30	5.4	9.4	15.5	23.9	34.6	
		60	7.4	12.9	20.2	29.4	40.1	
		90	10.6	16.8	25.0	34.4	45.8	
00	A and B	30	6.8	12.0	19.1	28.8	39.8	
		60	9.6	16.2	24.3	34.0	45.6	
		90	13.6	20.5	28.8	39.5	51.4	
	C	30	4.8	8.3	13.0	19.3	27.6	
		60	6.6	11.2	17.5	24.4	33.3	
		90	9.5	15.3	22.0	30.3	40.1	
0000	A and B	30	5.8	9.6	14.8	21.4	28.8	
		60	8.2	13.3	19.3	26.7	35.3	
		90	11.3	17.4	24.5	32.8	40.8	
	C	30	4.4	7.2	10.8	15.5	20.6	
		60	5.9	9.7	14.2	20.0	26.4	
		90	8.5	13.3	18.5	25.2	32.2	

Table 47.—Sags for T. B. W. P. Solid Soft Copper Wire—Continued

MEDIUM LOADING DISTRICTS

[The sags being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of— 100	125	150	175	200	250
		° F.						
6	C	30	8.8	19.7	33.8			
		60	12.2	23.8	38.2			
		90	15.8	27.7	42.1			
4	A and B	30	8.3	16.8	28.3	42.2		
		60	11.9	21.0	32.6	47.1		
		90	15.5	25.5	37.1	51.0		
	C	30	5.5	10.0	18.0	28.4		
		60	7.6	13.8	22.5	34.1		
		90	10.6	18.0	27.9	38.7		
2	A and B	30	6.0	10.5	16.9	26.9	37.2	
		60	8.3	14.1	21.8	31.7	43.2	
		90	11.7	18.4	26.8	37.6	48.7	
	C	30	4.4	7.5	11.5	17.6	25.9	
		60	6.0	10.0	15.3	22.7	31.2	
		90	8.0	13.5	19.6	27.7	37.4	
1	A and B	30	5.5	9.3	14.4	21.8	31.2	53.4
		60	7.4	12.7	18.7	27.1	36.7	60.6
		90	10.7	16.8	24.1	33.2	43.0	66.9
	C	30	4.1	6.9	10.4	14.7	21.6	38.4
		60	5.5	8.9	13.3	19.1	26.8	45.0
		90	7.4	11.8	17.8	23.9	32.6	52.2
0	A and B	30	5.3	8.9	13.3	19.3	26.6	47.4
		60	7.3	11.7	18.0	23.9	32.4	53.7
		90	10.1	16.1	22.5	30.0	38.6	61.0
	C	30	4.1	6.6	10.1	14.3	19.7	34.2
		60	5.4	8.7	13.0	18.3	24.5	40.5
		90	7.4	11.7	16.9	23.1	30.3	47.7
00	A and B	30	4.9	8.1	12.2	17.2	23.5	39.6
		60	6.7	10.9	16.0	22.0	28.8	47.4
		90	9.6	14.7	20.9	27.3	35.8	54.0
	C	30	3.8	6.5	9.4	12.8	17.7	29.7
		60	4.9	8.3	12.1	16.4	22.3	35.4
		90	6.8	11.1	15.8	20.8	28.1	42.6
0000	A and B	30	4.6	7.4	10.8	15.3	20.3	33.3
		60	6.2	10.0	14.4	19.3	25.7	39.9
		90	9.0	13.6	18.9	25.0	31.7	47.4
	C	30	3.7	5.9	8.6	12.2	15.6	25.8
		60	4.8	7.5	11.2	15.1	19.9	31.5
		90	6.7	10.3	14.6	19.1	24.8	38.1

Table 47.—Sags for T. B. W. P. Solid Soft Copper Wire—Continued

LIGHT LOADING DISTRICT

[The sags being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (inches) for span lengths (feet) of— 100	125	150	175	200	250
6	A and B	30	6.1	11.2	18.7			
		60	8.4	14.8	23.4			
		90	11.5	18.9	28.3			
	C	30	5.0	7.8	12.2			
		60	6.6	10.1	15.8			
		90	8.8	13.3	18.9			
4	A and B	30	4.8	8.4	12.8	19.7	28.3	
		60	6.5	11.1	16.6	24.1	34.1	
		90	9.1	14.7	21.2	29.8	40.3	
	C	30	4.0	6.2	9.4	13.8	19.2	
		60	4.9	7.9	11.9	17.6	23.9	
		90	6.6	10.5	15.5	22.0	29.7	
2	A and B	30	4.7	7.5	10.8	15.9	22.1	37.2
		60	6.0	9.6	14.2	20.0	26.8	43.8
		90	8.4	12.9	18.4	24.8	32.6	51.0
	C	30	3.7	5.7	8.5	11.8	16.6	27.6
		60	4.6	7.4	10.4	14.7	20.3	33.3
		90	6.2	9.6	13.7	18.9	25.0	39.3
1	A and B	30	4.3	6.9	10.3	13.8	19.2	33.0
		60	5.6	9.1	13.0	18.5	23.9	39.3
		90	7.8	12.3	17.3	23.1	29.7	47.1
	C	30	3.4	5.5	7.9	11.1	15.1	25.2
		60	4.3	6.9	10.1	13.8	18.2	30.3
		90	5.9	9.1	13.1	17.6	23.4	36.6
0	A and B	30	4.2	6.8	10.1	14.3	18.7	31.8
		60	5.8	8.9	12.8	17.4	23.7	37.2
		90	7.8	12.0	17.1	22.3	29.1	43.5
	C	30	3.7	5.5	7.9	11.1	14.9	24.3
		60	4.4	7.1	10.1	13.6	18.5	30.0
		90	6.0	9.1	13.0	17.4	23.0	36.0
00	A and B	30	4.1	6.3	9.7	13.0	17.5	29.4
		60	5.3	8.7	12.2	16.4	21.8	34.8
		90	7.6	11.7	16.0	21.4	27.6	42.0
	C	30	3.2	5.4	7.9	10.9	14.4	22.8
		60	4.2	6.6	9.7	13.4	17.5	27.6
		90	5.6	8.9	12.6	17.0	21.8	33.9
0000	A and B	30	3.8	6.0	9.0	12.4	16.3	25.8
		60	5.2	8.1	11.7	15.5	20.6	31.8
		90	7.2	10.8	15.5	20.2	25.9	38.4
	C	30	3.1	5.1	7.7	10.3	13.7	21.0
		60	4.1	6.3	9.4	12.6	16.8	25.8
		90	5.5	8.4	12.1	16.2	20.9	31.5

Table 48.—Sags for Ordinary Grade Steel Wire

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		° F.									
8	C	30	4.1	12.5	26.0	------	------	------	------	------	------
		60	6.2	16.5	30.0	------	------	------	------	------	------
		90	11.1	20.0	33.5	------	------	------	------	------	------
6	A and B	30	4.7	12.0	24.5	------	------	------	------	------	------
		60	7.4	16.0	28.5	------	------	------	------	------	------
		90	11.0	20.0	32.0	------	------	------	------	------	------
	C	30	2.5	5.4	11.2	22.0	35.0	65.0	104	213	341
		60	3.6	7.7	15.5	27.0	40.5	70.0	109	216	344
		90	5.3	11.2	20.5	31.5	45.0	75.0	113	220	348
4	A and B	30	3.1	6.6	13.0	22.0	34.5	64.0	99	189	309
		60	4.7	9.8	17.5	27.5	40.0	69.0	104	193	314
		90	7.4	14.0	22.0	32.5	44.0	73.0	108	197	318
	C	30	2.2	3.7	6.3	11.1	18.0	41.0	71	147	245
		60	2.8	5.1	9.2	15.5	24.0	47.5	77	152	250
		90	4.0	7.2	12.5	20.5	29.5	53.0	82	158	256

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 15° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

8	C	30	1.9	3.1	5.2	------	------	------	------	------	------
		60	2.4	4.1	6.8	------	------	------	------	------	------
		90	3.1	5.5	9.7	------	------	------	------	------	------
6	A and B	30	2.2	3.9	6.3	------	------	------	------	------	------
		60	2.9	5.3	8.6	------	------	------	------	------	------
		90	4.3	7.5	12.0	------	------	------	------	------	------
	C	30	1.7	2.7	4.3	6.3	9.4	18.5	34.5	85	161
		60	2.0	3.5	5.4	8.2	12.0	23.5	42.0	93	169
		90	2.6	4.5	7.2	11.1	16.0	30.5	49.5	101	177
4	A and B	30	2.0	3.4	5.4	7.8	11.3	22.0	38.5	88	150
		60	2.6	4.5	7.0	10.7	15.0	28.0	46.0	96	158
		90	3.8	6.3	9.9	14.5	20.0	34.5	53.0	104	166
	C	30	1.7	2.7	4.0	5.7	7.7	14.0	23.5	58	107
		60	2.0	3.3	4.9	6.9	9.6	17.5	29.0	67	117
		90	2.5	4.2	6.3	9.2	12.5	23.0	36.0	76	127

Table 48.—Sags for Ordinary Grade Steel Wire—Continued

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 30° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C.]

Steel wire gage No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		° F.									
8	C	30	1.4	2.2	3.2						
		60	1.7	2.8	4.0						
		90	2.2	3.3	4.9						
6	A and B	30	1.8	2.7	3.9						
		60	2.3	3.5	5.0						
		90	2.8	4.4	6.3						
	C	30	1.4	2.2	3.2	4.6	5.8	9.6	14.5	27.5	48
		60	1.7	2.7	4.0	5.5	7.2	11.7	17	32.0	55
		90	2.2	3.3	4.7	6.5	8.9	14.0	21	39.0	64
4	A and B	30	1.7	2.7	4.0	5.5	7.2	11.7	17.5	33.5	54
		60	2.2	3.5	4.9	6.7	9.1	14.5	21.5	40.5	67
		90	2.8	4.5	6.3	8.8	11.5	18.5	26.5	48.0	77
	C	30	1.4	2.3	3.3	4.6	6.0	9.3	13.5	26.0	43
		60	1.7	2.7	4.0	5.5	7.2	11.4	17	30.5	50
		90	2.1	3.3	4.7	6.5	8.6	14.0	20	37.0	59

Table 49.—Sags for Siemens-Martin Steel Wire

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° F.								
6	C	30	13.5	35.5	67.0	147	251	379	528	
		60	18.5	42.5	73.0	152	256	384	533	
		90	23.5	48.5	79.0	158	261	389	538	
4	A and B	30	15.0	37.0	65.0	136	231	357	487	
		60	20.5	43.5	72.0	143	237	362	492	
		90	26.0	50.0	78.0	148	242	367	498	
	C	30	8.2	17.5	36.0	94	172	268	382	815
		60	10.6	22.5	43.0	102	179	276	388	822
		90	14.0	29.0	51.0	110	188	282	395	830

Table 49.—Sags for Siemens-Martin Steel Wire—Continued

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 15° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° F.								
6	C	30	5.5	10.5	17.5	48	100	161	242	550
		60	7.0	12.5	21.5	54	109	171	251	564
		90	8.7	16.0	27.0	63	119	181	262	578
4	A and B	30	7.2	12.5	21.0	52	98	162	235	534
		60	9.1	16.0	26.5	60	109	171	246	545
		90	11.5	20.0	33.0	70	118	182	255	555
	C	30	5.3	9.0	14.0	31	61	109	168	408
		60	6.3	11.1	17.0	37	71	120	182	420
		90	7.7	13.0	20.0	45	82	131	193	432

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 30° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	200	250	300	400	500	600	700	1,000
6	C	30	4.8	7.5	10.8	20.0	33.0	50	73	178
		60	5.3	8.4	12.5	23.0	38.0	58	83	196
		90	6.2	10.2	15.0	27.0	44.0	66	94	212
4	A and B	30	5.5	8.7	13.0	24.5	40.0	62	90	212
		60	6.7	10.8	15.5	29.0	47.5	72	103	229
		90	8.2	13.0	18.5	34.5	55.0	83	116	245
	C	30	4.8	7.2	10.4	18.5	32.0	49	69	158
		60	5.3	8.4	12.0	22.0	36.5	54	77	174
		90	6.2	9.9	14.5	26.0	42.0	62	86	192

Table 50.—Sags for High-Tension Steel Wire

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of— 200	250	300	400	500	600	700	1,000
		° F.								
6	C	30	3.6	6.0	9.7	25.0	66.0	130	218	595
		60	4.0	6.8	11.2	30.0	75.0	143	231	602
		90	4.3	7.5	12.5	34.5	87.0	154	244	610
4	A and B	30	4.1	7.2	11.5	29.5	71.0	135	215	537
		60	4.7	8.2	13.5	34.5	82.0	147	225	547
		90	5.3	9.3	16.0	42.0	92.0	159	237	556
	C	30	3.4	5.2	7.9	16.5	34.0	68	126	394
		60	3.7	5.8	8.8	19.0	39.5	79	140	405
		90	4.1	6.4	9.7	21.5	45.5	89	154	419

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 15° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

6	C	30	3.1	4.6	6.8	12.5	23.0	36.0	60	202
		60	3.4	5.2	7.5	14.0	25.0	41.0	67	216
		90	3.7	5.8	8.3	16.0	27.5	47.0	77	234
4	A and B	30	3.8	5.7	8.3	15.5	27.5	45.5	71	216
		60	4.2	6.4	9.4	18.0	32.0	52.0	82	233
		90	4.6	7.2	10.5	20.5	36.0	59.0	92	248
	C	30	3.1	4.8	6.8	12.0	20.0	31.0	46	132
		60	3.3	5.2	7.5	13.0	21.5	33.0	51	146
		90	3.6	5.7	8.3	14.5	24.0	37.5	57	162

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 30° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

6	C	30	2.9	4.5	6.5	11.1	18.0	26.0	35.5	75
		60	3.3	4.9	6.8	12.0	19.0	27.5	38.5	81
		90	3.6	5.3	7.5	13.0	20.5	29.5	42.0	90
4	A and B	30	3.6	5.7	7.9	13.5	20.5	29.5	41.5	95
		60	3.9	6.1	8.6	14.5	22.5	33.0	46.0	104
		90	4.3	6.6	9.4	16.0	24.5	37.5	52.0	114
	C	30	2.9	4.2	6.1	10.6	17.0	25.0	34.5	74
		60	3.1	4.8	6.8	11.8	18.5	27.5	38.0	80
		90	3.4	5.4	7.6	13.0	20.5	30.5	41.0	86

Table 51.—Sags for Ordinary Grade Steel Cable

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
¼	A and B	30	3.8	8.9	19.0	32.5	48.0	86.0	131	250	406
		60	5.4	12.5	23.0	36.5	52.0	90.0	135	254	409
		90	7.8	16.0	27.0	40.5	56.0	93.0	138	257	413
	C	30	2.3	4.5	8.5	16.0	28.0	58.0	97.0	195	323
		60	2.0	5.9	11.4	20.5	33.0	63.0	102	200	328
		90	3.8	7.8	15.0	25.0	38.0	68.0	106	205	332
5/16	A and B	30	2.6	4.8	7.9	13.0	20.5	43.0	72.0	147	241
		60	3.6	6.3	10.8	17.0	25.5	48.5	78.0	151	247
		90	4.7	8.4	14.0	21.0	31.0	54.0	83.0	157	252
	C	30	1.9	3.3	5.2	7.8	11.5	24.0	44.0	105	185
		60	2.3	4.1	6.3	9.9	14.5	29.0	51.0	112	191
		90	2.9	5.2	8.1	12.5	18.0	35.0	58.0	118	199
⅜	A and B	30	2.4	4.2	6.7	10.1	14.5	29.0	49.5	107	183
		60	3.1	5.4	8.6	13.0	18.5	35.0	56.0	114	190
		90	4.3	7.0	11.2	16.5	23.0	40.5	63.0	121	197
	C	30	1.9	3.1	4.7	6.7	9.6	17.5	30.0	73.0	134
		60	2.3	3.7	5.6	8.2	11.8	21.5	36.0	81.0	142
		90	2.8	4.6	7.0	10.3	14.5	26.5	42.0	89.0	151
7/16	A and B	30	2.3	3.9	5.8	8.4	11.5	21.0	34.0	75.0	131
		60	2.9	5.0	7.4	10.7	14.5	25.5	40.5	83.0	139
		90	3.8	6.3	9.7	13.5	18.5	31.0	47.5	91.0	148
	C	30	1.9	3.0	4.3	6.3	8.6	14.5	22.5	50.0	92
		60	2.2	3.5	5.2	7.4	10.1	17.0	27.0	57.0	102
		90	2.6	4.4	6.5	9.0	12.0	21.0	32.5	66.0	112
½	A and B	30	2.3	3.7	5.6	8.0	11.0	19.0	30.0	66.0	116
		60	2.9	4.8	7.0	10.1	13.5	23.5	36.5	74.0	125
		90	3.8	6.1	9.2	13.0	17.5	28.5	43.0	83.0	135
	C	30	1.9	3.0	4.3	6.1	8.2	13.5	21.0	44.0	80
		60	2.2	3.5	5.2	7.1	9.8	16.0	25.0	51.0	91
		90	2.5	4.2	6.3	8.8	12.0	19.5	30.0	59.0	100
9/16	A and B	30	2.3	3.6	5.4	7.6	10.3	17.0	26.5	54.0	94
		60	2.8	4.7	6.7	9.5	12.5	21.0	31.5	62.0	104
		90	3.7	6.0	8.6	12.0	16.0	26.0	37.5	70.0	113
	C	30	1.9	3.0	4.3	5.9	7.7	12.5	19.5	38.5	66
		60	2.2	3.5	5.0	6.9	9.4	15.0	23.0	44.5	75
		90	2.6	4.2	6.1	8.4	11.0	18.5	27.5	51.0	85
⅝	A and B	30	2.2	3.6	5.4	7.6	10.1	16.0	25.0	49.0	85
		60	2.8	4.5	6.5	9.3	12.0	20.0	29.5	57.0	94
		90	3.7	5.8	8.6	11.8	15.5	24.5	35.5	65.0	103
	C	30	1.9	3.0	4.3	5.9	7.7	12.5	18.5	35.5	61
		60	2.2	3.4	4.9	6.7	9.1	14.5	22.0	41.5	69
		90	2.5	4.2	6.1	8.4	11.0	17.5	26.0	48.0	78

Table 51.—Sags for Ordinary Grade Steel Cable—Continued

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 15° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
¼	A and B	30	2.3	3.9	6.1	9.9	14.5	30.5	55.0	117.0	201.0
		60	2.9	5.1	7.9	13.0	18.5	36.0	62.0	124.0	208.0
		90	3.8	6.4	10.4	16.0	23.5	42.5	68.0	130.0	214.0
	C	30	1.9	3.0	4.5	6.5	9.4	17.5	31.5	81.0	151.0
		60	2.2	3.5	5.4	8.0	11.0	21.5	37.5	88.0	160.0
		90	2.5	4.4	6.5	9.9	14.0	26.5	44.5	97.0	167.0
5/16	A and B	30	2.2	3.5	5.2	7.6	10.3	18.5	29.5	66.0	120.0
		60	2.6	4.2	6.5	9.2	12.5	22.5	35.5	75.0	130.0
		90	3.2	5.4	8.1	11.6	16.0	27.5	41.5	83.0	138.0
	C	30	1.9	2.8	4.1	5.7	7.7	13.0	20.0	43.5	82.0
		60	2.0	3.3	4.5	6.7	9.1	15.5	24.0	51.0	91.0
		90	2.3	3.9	5.8	8.0	10.8	18.5	28.5	58.0	101.0
⅜	A and B	30	2.0	3.3	4.9	6.9	9.3	15.5	25.0	52.0	94.0
		60	2.5	4.2	6.1	8.6	11.5	19.0	30.0	60.0	103.0
		90	3.2	5.3	7.7	10.9	14.0	24.0	35.5	68.0	113.0
	C	30	1.8	2.8	4.1	5.7	7.4	12.0	18.0	36.5	65.0
		60	2.0	3.2	4.7	6.5	8.6	14.0	21.5	42.0	73.0
		90	2.3	3.6	5.6	7.6	10.3	16.5	25.0	49.0	83.0
7/16	A and B	30	2.0	3.3	4.7	6.7	8.9	14.5	22.0	43.0	74.0
		60	2.5	4.0	5.8	8.2	10.8	17.5	26.5	50.0	84.0
		90	3.2	5.1	7.4	10.3	13.5	21.5	31.5	57.0	93.0
	C	30	1.8	2.8	4.0	5.5	7.2	11.4	16.5	31.5	55.0
		60	2.0	3.2	4.5	6.3	8.4	13.0	20.0	37.5	62.0
		90	2.3	3.8	5.4	7.6	9.8	15.5	23.0	43.0	70.0
½	A and B	30	2.0	3.3	4.9	6.7	8.9	14.0	21.5	41.0	69.0
		60	2.5	4.1	5.8	8.0	10.6	17.0	25.5	47.5	79.0
		90	3.2	5.1	7.4	10.1	13.0	21.0	30.0	55.0	88.0
	C	30	1.8	2.7	4.0	5.4	7.2	11.4	16.5	31.0	52.0
		60	2.0	3.1	4.5	6.3	8.4	13.0	19.0	36.0	59.0
		90	2.3	3.7	5.4	7.3	9.8	15.5	22.5	42.0	67.0
9/16	A and B	30	2.0	3.3	4.7	6.5	8.6	14.0	20.5	39.0	63.0
		60	2.4	3.9	5.8	8.0	10.6	16.0	24.0	44.5	71.0
		90	3.1	4.9	7.2	9.9	12.5	20.0	29.0	52.0	81.0
	C	30	1.8	2.7	4.0	5.5	7.2	11.1	16.0	30.0	48.5
		60	2.0	3.0	4.5	6.3	8.2	12.5	18.5	34.0	55.0
		90	2.3	3.6	5.4	7.3	9.6	15.0	22.0	40.5	62.0
⅝	A and B	30	2.0	3.3	4.7	6.5	8.6	13.5	20.0	37.0	60.0
		60	2.4	3.9	5.6	7.8	10.3	16.0	23.5	42.5	69.0
		90	3.1	5.1	7.2	9.7	12.5	19.5	28.0	50.0	78.0
	C	30	1.8	2.7	4.0	5.4	7.0	10.8	16.0	29.0	47.5
		60	2.0	3.2	4.5	6.1	7.9	12.5	18.5	33.0	54.0
		90	2.3	3.8	5.4	7.4	9.6	14.5	21.5	39.0	61.0

Table 51.—Sags for Ordinary Grade Steel Cable—Continued

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 30° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
1/4	A and B	30	1.9	3.0	4.5	6.3	8.5	14.0	21.0	41.5	74.0
		60	2.3	3.6	5.4	7.6	10.2	16.5	25.0	48.5	84.0
		90	2.8	4.6	6.5	9.0	12.0	19.5	29.5	56.0	94.0
	C	30	1.8	2.7	3.8	5.2	6.7	10.8	16.0	31.7	54.0
		60	1.9	3.0	4.5	6.1	7.9	12.5	18.5	36.0	61.0
		90	2.0	3.3	5.0	6.9	9.4	14.5	21.5	41.7	70.0
5/16	A and B	30	1.9	3.0	4.5	6.1	8.1	12.5	18.5	36.0	60.0
		60	2.2	3.6	5.4	7.3	9.6	15.0	22.5	42.0	68.0
		90	2.6	4.3	6.5	8.8	11.3	18.5	26.5	48.5	77.0
	C	30	1.7	2.7	3.8	5.0	6.7	10.2	15.0	28.5	47.0
		60	1.8	3.0	4.3	5.9	7.7	12.0	17.5	32.0	53.0
		90	2.0	3.3	4.9	6.7	8.9	14.0	20.0	37.0	60.0
3/8	A and B	30	1.9	3.0	4.3	5.9	7.9	12.5	18.5	34.5	57.0
		60	2.3	3.6	5.2	7.1	9.4	15.0	22.0	40.5	65.0
		90	2.8	4.3	6.3	8.6	11.3	17.5	26.0	46.5	73.0
	C	30	1.7	2.7	3.8	5.0	6.6	10.5	15.0	27.5	45.0
		60	1.9	3.0	4.3	5.7	7.4	11.7	17.5	31.0	51.0
		90	2.2	3.4	4.9	6.7	8.6	13.5	20.0	36.0	58.0
7/16	A and B	30	1.9	3.0	4.3	5.9	7.7	12.5	18.0	33.0	53.0
		60	2.2	3.5	5.0	7.1	9.4	14.5	21.0	38.5	61.0
		90	2.6	4.3	6.2	8.6	11.3	17.5	25.0	44.5	68.0
	C	30	1.7	2.7	3.8	5.0	6.5	10.2	15.0	27.0	43.0
		60	1.9	3.0	4.3	5.7	7.4	11.4	16.5	30.0	48.5
		90	2.2	3.3	4.9	6.7	8.7	13.5	19.5	34.5	55.0
1/2	A and B	30	1.8	3.0	4.3	5.9	7.7	12.5	18.0	32.5	53.0
		60	2.2	3.6	5.2	7.1	9.1	14.5	21.0	38.5	60.0
		90	2.6	4.3	6.1	8.6	11.0	17.0	25.0	44.0	68.0
	C	30	1.8	2.7	3.8	5.0	6.5	10.2	15.0	27.0	42.5
		60	1.9	3.0	4.3	5.7	7.4	11.7	16.5	30.0	48.0
		90	2.0	3.3	4.9	6.7	8.9	13.5	19.5	34.5	55.0
9/16	A and B	30	1.9	3.0	4.3	5.9	7.7	12.0	17.5	31.5	52.0
		60	2.2	3.5	5.0	6.9	9.1	14.0	21.0	37.5	58.0
		90	2.6	4.4	6.1	8.4	11.0	17.0	24.5	43.0	66.0
	C	30	1.8	2.7	3.8	5.0	6.5	10.2	15.0	26.0	42.0
		60	1.9	3.0	4.2	5.7	7.5	11.4	16.5	30.0	47.0
		90	2.0	3.3	4.8	6.5	8.6	13.0	19.0	34.0	53.0
5/8	A and B	30	1.9	3.0	4.3	5.9	7.7	12.0	17.5	31.5	50.0
		60	2.2	3.5	5.0	6.9	9.0	14.0	20.5	37.0	58.0
		90	2.6	4.2	6.2	8.4	11.0	17.0	24.5	43.0	65.0
	C	30	1.7	2.7	3.8	5.0	6.5	10.2	15.0	26.0	41.5
		60	1.9	3.0	4.3	5.7	7.4	11.4	16.5	30.0	47.0
		90	2.2	3.5	4.9	6.5	8.4	13.0	19.5	33.5	53.0

Table 52.—Sags for Siemens-Martin Steel Cable

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° F.								
5/16	A and B	30	10.3	20.5	39.5	96.0	166.0	270	381	792
		60	12.5	25.0	46.0	103.0	176.0	280	389	799
		90	16.0	31.0	53.0	110.0	188.0	287	396	806
	C	30	7.0	12.5	22.0	57.0	119.0	197	289	664
		60	8.2	15.5	26.0	66.0	127.0	205	297	672
		90	9.6	18.5	31.5	74.0	137.0	213	306	680
3/8	A and B	30	8.9	15.5	26.5	64.0	123.0	198	288	640
		60	10.6	19.0	32.0	72.0	131.0	208	295	649
		90	12.5	23.5	38.0	80.0	140.0	216	302	657
	C	30	6.5	10.8	17.5	39.5	77.0	137	208	499
		60	7.5	12.5	20.0	45.5	87.0	144	218	509
		90	8.6	14.5	24.0	52.0	96.0	155	229	520
7/16	A and B	30	7.9	13.0	21.0	45.0	84.0	140	203	479
		60	9.4	15.5	24.5	51.0	93.0	150	214	487
		90	11.3	19.0	29.5	59.0	103.0	159	224	496
	C	30	6.0	9.9	15.0	30.0	55.0	93	144	358
		60	6.9	11.4	17.5	35.0	63.0	104	154	370
		90	7.9	13.0	20.0	40.5	71.0	115	167	383
1/2	A and B	30	7.4	12.5	20.0	41.0	73.0	121	179	414
		60	9.1	15.5	23.5	47.0	83.0	131	190	426
		90	11.0	18.0	27.5	55.0	92.0	142	201	438
	C	30	6.2	9.9	15.0	29.0	50.0	82	123	312
		60	7.0	11.3	17.0	33.0	57.0	92	136	326
		90	7.9	12.5	19.0	37.5	65.0	102	148	340
9/16	A and B	30	7.4	12.0	18.0	35.0	61.0	98	145	337
		60	9.0	14.0	21.0	41.0	69.0	109	158	350
		90	10.6	17.0	25.0	47.5	79.0	119	170	364
	C	30	6.0	9.5	14.0	25.5	44.0	69	103	253
		60	6.8	10.9	16.0	30.0	51.0	78	113	269
		90	7.7	12.5	18.0	34.0	57.0	87	125	285
5/8	A and B	30	7.2	11.8	17.5	33.5	57.0	88	130	301
		60	8.7	14.0	20.5	39.5	64.0	98	140	315
		90	10.3	16.0	24.0	45.0	73.0	109	153	330
	C	30	5.8	9.4	13.5	25.5	42.0	64	93	227
		60	6.6	10.8	15.5	29.0	47.5	71	104	241
		90	7.4	12.0	17.5	32.5	53.0	81	115	260

Table 52.—Sags for Siemens-Martin Steel Cable—Continued

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 15° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
5/16	A and B	30	7.2	12.0	18.5	40.0	75.0	124	186	442
		60	8.6	14.5	22.0	46.0	85.0	134	197	453
		90	10.1	17.0	25.5	53.0	94.0	145	208	465
	C	30	5.8	9.4	13.5	27.5	49.0	81	128	331
		60	6.6	10.7	16.0	31.5	55.0	91	139	344
		90	7.4	12.0	18.0	35.5	63.0	101	150	358
3/8	A and B	30	7.2	11.4	17.5	33.5	60.0	99	144	348
		60	8.4	13.0	20.0	40.5	69.0	109	157	361
		90	9.6	15.5	24.0	47.5	78.0	120	171	378
	C	30	5.8	9.3	13.5	25.0	42.5	67	102	256
		60	6.5	10.5	15.5	29.0	48.5	76	113	272
		90	7.2	11.7	17.5	32.5	54.0	85	124	287
7/16	A and B	30	6.7	10.8	16.0	30.0	51.0	79	114	273
		60	8.0	13.0	18.5	35.0	57.0	88	127	287
		90	9.4	15.0	21.5	40.0	65.0	98	137	301
	C	30	5.8	9.0	12.5	24.0	38.5	58	85	203
		60	6.5	10.0	14.5	27.0	44.0	65	93	216
		90	7.2	11.1	16.0	30.0	49.5	73	103	232
1/2	A and B	30	7.0	10.8	16.0	29.5	48.0	73	104	251
		60	8.2	12.5	18.5	34.0	55.0	84	117	268
		90	9.4	14.5	21.0	39.0	63.0	93	129	282
	C	30	5.7	8.7	12.5	23.5	37.0	56	81	188
		60	6.4	9.9	14.0	26.5	42.0	62	88	202
		90	7.2	11.1	16.0	29.5	47.5	69	98	219
9/16	A and B	30	6.7	10.5	15.5	28.0	46.0	68	98	221
		60	7.9	12.5	17.5	32.5	53.0	78	108	236
		90	9.1	14.0	20.5	37.5	59.0	86	119	251
	C	30	5.5	8.7	12.5	23.0	36.5	54	76	164
		60	6.3	9.9	14.0	26.0	41.0	60	83	181
		90	7.2	11.0	16.0	29.0	45.5	66	93	194
5/8	A and B	30	6.7	10.5	15.0	28.0	45.0	66	93	210
		60	7.9	12.0	17.5	32.0	51.0	75	104	222
		90	9.1	14.0	20.0	36.5	58.0	84	114	240
	C	30	5.5	8.7	12.5	22.5	36.0	53	73	162
		60	6.2	9.7	14.0	25.5	40.5	58	80	175
		90	7.0	10.8	16.0	28.5	45.0	65	89	189

Table 52.—Sags for Siemens-Martin Steel Cable—Continued

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 30° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° *F.*								
5/16	A and B	30	6.5	10.2	15.0	26.5	44.0	66.0	94	221
		60	7.4	11.7	17.0	30.5	50.0	74.0	104	235
		90	8.4	13.0	19.0	35.0	56.0	83.0	115	250
	C	30	5.3	8.1	11.9	21.5	35.0	51.0	73	165
		60	6.0	9.3	13.5	24.0	39.0	57.0	81	179
		90	6.7	10.5	15.0	27.0	43.0	63.0	88	194
3/8	A and B	30	6.2	9.9	14.5	26.0	43.0	63.0	90	203
		60	7.2	11.4	16.5	29.5	49.0	72.0	100	218
		90	8.2	13.0	19.0	33.5	55.0	81.0	110	234
	C	30	5.3	8.6	12.0	21.5	35.0	50.0	71	156
		60	6.0	9.6	13.5	24.0	39.0	57.0	78	170
		90	6.7	10.6	15.0	26.5	43.0	63.0	86	184
7/16	A and B	30	6.2	9.6	14.5	25.5	41.0	60.0	84	182
		60	7.2	11.1	16.5	29.5	46.5	67.0	93	198
		90	8.2	12.5	18.5	33.5	52.0	75.0	102	212
	C	30	5.3	8.5	11.9	20.5	33.5	48.0	67	145
		60	6.0	9.6	13.5	23.0	37.5	54.0	74	157
		90	6.7	10.7	15.0	26.0	41.5	59.0	82	170
1/2	A and B	30	6.2	9.7	14.0	25.5	41.0	60.0	83	180
		60	7.2	11.1	16.5	29.5	46.5	67.0	91	194
		90	8.2	12.5	18.5	33.5	52.0	75.0	102	210
	C	30	5.3	8.4	11.9	20.5	33.5	48.0	67	144
		60	5.9	9.5	13.5	23.0	37.0	54.0	74	156
		90	6.5	10.2	15.0	26.0	41.0	59.0	81	169
9/16	A and B	30	6.2	9.9	14.0	25.0	40.0	59.0	81	168
		60	7.2	11.3	16.0	28.5	45.5	66.0	90	184
		90	8.3	12.5	18.0	32.0	50.0	73.0	99	201
	C	30	5.3	8.1	11.5	20.0	33.0	47.5	66	138
		60	6.0	9.3	13.5	23.0	36.5	53.0	73	150
		90	6.7	10.5	14.5	26.0	40.0	58.0	80	163
5/8	A and B	30	6.2	9.9	14.0	25.0	39.5	58.0	80	169
		60	7.2	11.2	16.0	28.5	45.0	65.0	87	181
		90	8.2	12.5	18.0	32.5	50.0	72.0	98	198
	C	30	5.3	8.1	11.5	20.5	32.5	47.0	65	134
		60	5.9	9.1	13.0	23.0	36.5	53.0	72	147
		90	6.5	10.2	14.5	26.0	40.0	58.0	79	160

Table 53.—Sags for High-Tension Steel Cable

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° F.								
5/16	A and B	30	4.3	6.9	10.4	22.0	43.0	78.0	134	391
		60	4.8	7.6	11.7	24.0	47.5	88.0	147	405
		90	5.3	8.4	13.0	27.0	54.0	97.0	159	418
	C	30	3.1	4.8	7.2	15.0	26.5	45.5	74.0	252
		60	3.4	5.4	7.9	16.5	30.0	50.0	82.0	270
		90	3.8	6.0	8.6	17.5	33.5	56.0	90.0	284
3/8	A and B	30	4.1	6.3	9.4	19.0	33.5	56.0	89.0	271
		60	4.5	7.2	10.8	21.0	37.0	62.0	99.0	286
		90	5.0	8.1	12.0	24.0	42.0	69.0	110.0	301
	C	30	3.1	5.4	7.6	14.5	23.5	37.0	57.0	162
		60	3.4	5.7	8.3	15.5	25.0	40.5	63.0	171
		90	3.8	6.3	8.9	16.5	28.0	44.5	70.0	180
7/16	A and B	30	4.0	6.3	9.0	17.5	29.0	44.5	67.0	181
		60	4.4	7.0	10.2	19.5	32.5	49.5	74.0	196
		90	4.8	7.8	11.4	21.5	35.5	55.0	81.0	211
	C	30	3.1	4.8	7.0	13.5	22.0	33.5	48.0	118
		60	3.3	5.2	7.5	14.5	23.5	36.0	51.0	127
		90	3.6	5.7	8.3	15.5	26.0	38.0	55.0	137
1/2	A and B	30	3.8	5.7	8.3	16.5	27.5	42.5	62.0	160
		60	4.3	6.6	9.7	18.0	30.5	47.5	69.0	173
		90	4.8	7.5	11.2	20.0	33.5	53.0	76.0	187
	C	30	3.1	5.0	7.2	13.5	21.5	32.5	45.5	109
		60	3.4	5.4	7.6	14.5	23.0	34.5	49.0	118
		90	3.6	5.7	8.2	15.5	24.0	36.5	52.0	126
9/16	A and B	30	3.8	5.7	8.3	15.5	26.5	39.5	57.0	134
		60	4.3	6.6	9.4	18.0	29.5	44.0	62.0	146
		90	4.8	7.5	10.8	20.0	32.5	48.0	69.0	158
	C	30	3.1	4.9	7.2	13.5	21.0	31.0	44.0	97
		60	3.4	5.4	7.7	14.5	22.0	33.0	46.0	106
		90	3.6	5.7	8.3	15.5	24.0	36.0	50.0	113
5/8	A and B	30	3.8	5.8	8.3	15.5	25.0	37.5	54.0	124
		60	4.3	6.6	9.4	17.5	28.0	42.0	60.0	134
		90	4.8	7.5	10.4	19.5	31.0	46.0	66.0	146
	C	30	3.1	4.9	7.2	13.0	21.0	30.5	43.0	90
		60	3.4	5.4	7.9	14.0	22.5	33.0	45.5	96
		90	3.6	5.8	8.6	15.0	24.0	35.0	48.0	106

55862°—27——19

Table 53.—Sags for High-Tension Steel Cable—Continued

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 15° F. the cable will be stressed to 60 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of— 200	250	300	400	500	600	700	1,000
		°F.								
5/16	A and B	30	3.8	5.7	8.4	15.5	27.5	41.0	61.0	166
		60	4.2	6.3	9.4	17.5	30.0	45.5	68.0	180
		90	4.6	6.9	10.4	19.5	33.0	50.0	75.0	194
	C	30	3.1	4.8	6.8	13.0	21.0	31.0	45.0	108
		60	3.3	5.1	7.5	14.0	22.5	33.0	48.0	117
		90	3.6	5.7	8.3	15.0	24.0	35.5	50.0	126
3/8	A and B	30	3.8	6.0	8.6	15.5	25.0	37.5	54.0	132
		60	4.2	6.4	9.3	17.0	28.0	41.5	60.0	144
		90	4.6	6.9	10.1	18.5	31.0	46.0	66.0	156
	C	30	2.9	5.0	7.2	13.0	20.5	29.5	43.0	101
		60	3.1	5.4	7.7	14.0	22.0	32.5	45.5	109
		90	3.4	5.8	8.4	15.0	23.5	34.5	48.0	118
7/16	A and B	30	3.8	6.0	8.6	15.5	24.0	36.0	49.5	118
		60	4.2	6.4	9.3	16.5	26.5	39.5	55.0	127
		90	4.6	7.0	10.1	18.0	29.5	43.0	61.0	136
	C	30	3.1	5.0	7.2	12.5	20.0	29.5	40.5	88
		60	3.4	5.4	7.6	13.5	21.5	32.0	43.0	94
		90	3.6	5.7	8.0	14.5	23.0	34.0	46.0	101
1/2	A and B	30	3.8	5.7	8.2	15.5	24.0	35.5	49.0	112
		60	4.1	6.3	9.0	17.0	26.5	39.0	54.0	120
		90	4.3	6.9	10.1	18.0	29.0	42.5	60.0	128
	C	30	3.1	4.8	6.8	12.5	20.0	29.0	39.5	87
		60	3.4	5.4	7.6	13.5	21.0	31.0	43.0	93
		90	3.6	5.7	8.3	14.5	22.0	33.0	46.0	100
9/16	A and B	30	3.6	5.7	8.3	15.5	24.0	35.5	48.5	106
		60	4.1	6.3	9.0	16.5	26.0	37.5	52.0	114
		90	4.6	7.0	10.1	18.0	29.0	41.0	57.0	123
	C	30	2.9	4.8	6.8	12.5	19.5	29.0	39.5	84
		60	3.1	5.1	7.6	13.5	21.0	31.0	42.0	89
		90	3.4	5.4	8.3	14.5	23.0	33.0	44.5	95
5/8	A and B	30	3.6	5.9	8.3	15.0	23.5	34.5	48.0	103
		60	4.1	6.3	9.0	16.0	26.0	37.5	52.0	112
		90	4.6	7.1	9.7	18.0	29.0	41.0	57.0	120
	C	30	2.9	5.0	7.2	12.5	20.0	29.0	40.5	83
		60	3.1	5.3	7.6	13.5	21.0	31.0	43.0	88
		90	3.4	5.6	7.9	14.5	23.0	33.0	45.5	93

Table 53.—Sags for High-Tension Steel Cable—Continued

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F, without load, the sags being such that when loaded at 30° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of— 200	250	300	400	500	600	700	1,000
		°F.								
5/16	A and B	30	3.6	5.7	8.0	14.5	23.0	34.0	47.0	104
		60	3.9	6.0	8.7	15.5	25.0	36.5	51.0	112
		90	4.3	6.6	9.4	17.0	27.0	40.5	55.0	120
	C	30	2.9	4.5	6.5	12.5	20.0	28.0	38.5	82
		60	3.1	4.8	7.0	13.0	21.0	30.0	41.5	87
		90	3.4	5.4	7.6	14.0	22.0	31.5	44.5	92
3/8	A and B	30	3.6	5.6	7.9	14.5	23.5	34.0	46.0	100
		60	3.9	6.0	8.4	16.0	25.0	36.5	50.0	107
		90	4.3	6.6	9.0	17.0	27.0	39.0	54.0	115
	C	30	2.9	4.5	6.5	12.0	19.0	27.5	38.5	81
		60	3.1	4.8	7.2	13.0	20.5	29.5	41.5	85
		90	3.4	5.2	7.9	14.0	22.0	31.5	44.5	90
7/16	A and B	30	3.4	5.7	8.3	14.5	23.0	33.0	46.0	96
		60	3.9	6.0	8.7	15.5	24.5	35.5	49.0	104
		90	4.3	6.3	9.0	16.5	26.5	38.0	52.0	112
	C	30	3.0	4.5	6.5	12.0	19.0	27.5	38.5	78
		60	3.2	4.9	7.2	13.0	20.5	29.0	40.5	83
		90	3.4	5.4	7.9	14.0	21.5	31.0	43.0	89
1/2	A and B	30	3.4	5.4	7.9	14.5	23.0	34.0	45.5	96
		60	3.8	6.0	8.6	15.5	24.5	35.5	48.5	104
		90	4.3	6.6	9.4	16.5	26.5	38.0	52.0	113
	C	30	2.9	4.8	6.8	12.0	18.5	27.5	38.0	78
		60	3.1	5.1	7.6	13.0	20.5	29.5	40.5	83
		90	3.4	5.5	8.3	14.0	22.0	31.5	43.0	88
9/16	A and B	30	3.6	5.7	8.3	14.5	23.0	33.0	45.5	95
		60	4.0	6.2	9.0	15.5	24.5	35.5	48.0	103
		90	4.3	6.6	9.4	16.5	26.5	37.5	51.0	110
	C	30	2.9	4.6	6.7	12.0	18.5	27.5	38.0	77
		60	3.1	4.9	7.2	13.0	20.0	29.0	40.5	83
		90	3.4	5.4	7.7	14.0	21.0	31.0	43.0	88
5/8	A and B	30	3.4	5.5	8.1	14.5	23.0	33.0	44.5	94
		60	3.8	6.0	8.5	15.5	24.0	35.5	48.0	102
		90	4.3	6.7	9.0	16.5	25.0	37.5	51.0	110
	C	30	2.9	4.5	6.5	12.0	19.0	27.5	37.0	77
		60	3.1	5.0	7.2	13.0	20.5	29.0	39.5	82
		90	3.4	5.4	7.9	14.0	21.5	31.0	43.0	88

Table 54.—Sags for Bare Copper-Covered Steel Wire (Ordinary Grade)

HEAVY LOADING DISTRICT

[The sags being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength]

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		F.									
6	A and B	30	1.7	3.2	5.9	10.9	------	------	------	------	------
		60	2.0	3.8	7.2	13.7	------	------	------	------	------
		90	2.3	4.9	9.4	17.3	------	------	------	------	------
4	do	30	1.7	2.9	4.6	7.0	10.8	27.4	57.4	------	------
		60	1.9	3.4	5.4	8.6	13.7	34.6	64.2	------	------
		90	2.3	4.0	6.6	10.8	17.4	39.6	70.7	------	------

MEDIUM LOADING DISTRICT

[The sags being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength]

8	B	30	1.4	2.3	3.6	------	------	------	------	------	------
		60	1.5	2.6	4.1	------	------	------	------	------	------
		90	1.7	2.9	4.7	------	------	------	------	------	------
6	A and B	30	1.4	2.2	3.3	4.8	------	------	------	------	------
		60	1.5	2.5	3.7	5.4	------	------	------	------	------
		90	1.6	2.8	4.3	6.3	------	------	------	------	------
4	do	30	1.4	2.3	3.4	4.7	6.4	10.9	17.6	41.7	------
		60	1.6	2.6	3.8	5.4	7.3	13.0	20.5	48.7	------
		90	1.9	3.0	4.4	6.3	8.4	14.8	24.2	56.5	------

LIGHT LOADING DISTRICT

[The sags being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength]

8	B	30	1.2	------	2.6	------	------	------	------	------	------
		60	1.3	------	2.9	------	------	------	------	------	------
		90	1.4	------	3.3	------	------	------	------	------	------
6	A and B	30	1.2	------	2.8	------	5.0	------	------	------	------
		60	1.4	------	3.1	------	5.5	------	------	------	------
		90	1.5	------	3.5	------	6.2	------	------	------	------
4	do	30	1.3	------	3.0	------	5.4	------	12.2	22.7	37.0
		60	1.5	------	3.3	------	6.0	------	13.5	25.5	41.4
		90	1.7	------	3.8	------	6.8	------	15.7	28.8	46.7

Table 55.—Sags for Bare Copper-Covered Steel Cable

HEAVY LOADING DISTRICT

[The sags being such that when loaded at 0° F. the cable will be stressed to 50 per cent of its ultimate strength]

Diameter (inch)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			200	250	300	400	500	600	800	1,000
		°F.								
5/16	A and B	30	5.6	9.3	15.0	34.6	73.8	------	------	------
		60	6.2	10.4	17.1	39.9	83.4	------	------	------
		90	7.0	11.9	19.7	45.6	93.4	------	------	------
3/8	do	30	5.6	9.1	13.7	27.4	49.9	85.6	202	------
		60	6.1	10.1	15.2	30.6	56.2	95.2	215	------
		90	6.9	11.4	17.3	34.8	63.5	106.0	228	------
7/16	do	30	5.7	9.2	13.8	26.6	46.8	77.0	172	316
		60	6.4	10.2	15.3	29.8	52.3	85.6	186	331
		90	7.2	11.5	17.2	33.6	58.8	95.0	200	345
1/2	do	30	5.7	9.1	13.4	25.2	42.7	67.0	146	265
		60	6.2	10.0	14.8	28.0	47.3	74.2	157	280
		90	7.0	11.1	16.5	31.2	52.8	82.2	171	295
9/16	do	30	5.8	9.1	13.4	25.1	41.3	63.7	131	234
		60	6.4	10.1	14.8	27.5	45.5	69.8	142	248
		90	7.1	11.2	16.5	31.1	50.4	77.0	154	262

Table 55.—Sags for Bare Copper-Covered Steel Cable—Continued

MEDIUM LOADING DISTRICT

[The sags being such that when loaded at 15° F. the cable will be stressed to 50 per cent of its ultimate strength]

Diameter (inch)	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—					
			100	250	400	600	800	1,000
		°F.						
5/16	A and B	30	1.2	7.7	21.5	58.1	--------	--------
		60	1.3	8.5	23.9	64.7	--------	--------
		90	1.4	9.5	26.7	72.2	--------	--------
3/8	do	30	1.2	8.0	21.5	54.0	110.0	--------
		60	1.4	8.8	23.6	59.5	119.0	--------
		90	1.5	9.8	26.4	66.4	130.0	--------
7/16	do	30	1.3	8.3	22.0	53.4	104.0	178
		60	1.4	9.1	24.2	58.6	114.0	194
		90	1.6	10.1	26.7	64.7	124.0	208
1/2	do	30	1.3	8.3	21.9	52.1	99.5	168
		60	1.4	9.1	24.0	56.9	108.0	180
		90	1.6	10.1	26.5	62.8	117.0	193
9/16	do	30	1.3	8.5	22.3	52.5	98.5	163
		60	1.5	9.3	24.4	57.1	106.0	175
		90	1.6	10.3	26.8	62.4	115.0	188

LIGHT LOADING DISTRICT

[The sags being such that when loaded at 30° F. the cable will be stressed to 50 per cent of its ultimate strength]

5/16	A and B	30	1.1	7.0	18.5	43.2	81.5	--------
		60	1.2	7.8	20.2	47.2	88.8	--------
		90	1.4	8.6	22.6	51.8	97.1	--------
3/8	do	30	1.2	7.5	19.3	44.5	82.5	134
		60	1.3	8.2	21.2	49.0	89.5	144
		90	1.4	9.1	23.3	53.5	98.5	156
7/16	do	30	1.3	7.8	20.2	46.3	84.7	137
		60	1.4	8.5	22.0	50.4	91.8	147
		90	1.5	9.4	24.2	55.2	98.6	159
1/2	do	30	1.3	7.9	20.4	46.6	84.8	136
		60	1.4	8.6	22.2	50.6	91.6	146
		90	1.5	9.4	24.3	55.1	99.1	157
9/16	do	30	1.3	8.1	21.6	47.8	86.7	137
		60	1.4	8.8	22.7	51.8	93.4	148
		90	1.5	9.7	24.9	56.3	101.0	159

Table 56.—Sags for Bare Stranded Aluminum

HEAVY LOADING DISTRICT

[Sags being such that when loaded at 0° F. the conductor will be stressed to 50 per cent of its ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of— 100	125	150	200	250	300	400	500	600
		°F.									
1	A and B	30	12.5	24.6	42.1	------	------	------	------	------	------
		60	18.2	30.3	47.2	------	------	------	------	------	------
		90	23.0	35.1	51.8	------	------	------	------	------	------
	C	30	4.3	12.3	26.6	------	------	------	------	------	------
		60	9.4	20.1	33.5	------	------	------	------	------	------
		90	16.1	26.4	39.6	------	------	------	------	------	------
0	A and B	30	7.4	16.2	31.0	63.4	109.0	170.0	294	------	------
		60	13.0	24.6	37.1	69.6	115.0	177.0	304	------	------
		90	19.7	30.0	44.6	75.4	120.0	182.0	310	------	------
	C	30	2.9	7.2	15.5	45.1	81.0	127.0	239	------	------
		60	6.2	14.1	25.2	53.3	88.8	133.0	246	------	------
		90	12.7	21.6	32.4	60.0	95.4	140.0	251	------	------
00	A and B	30	5.0	10.8	22.0	49.4	85.2	127.0	241	------	------
		60	10.8	18.6	29.5	56.6	91.2	133.0	247	------	------
		90	16.8	25.2	36.0	63.4	97.2	140.0	254	------	------
	C	30	2.6	5.1	9.7	29.7	60.6	96.5	189	------	462
		60	5.0	9.9	18.0	39.4	70.2	106.0	198	------	472
		90	10.8	17.4	26.3	48.0	78.0	114.0	207	------	479
000	A and B	30	3.8	7.5	14.0	37.4	73.2	102.0	197	------	469
		60	7.7	14.7	23.4	46.5	75.6	111.0	205	------	478
		90	14.6	21.9	31.0	54.2	84.0	119.0	213	------	487
	C	30	2.2	4.2	6.8	20.6	45.0	74.2	151	------	376
		60	3.8	7.5	13.3	31.2	56.4	92.2	161	------	387
		90	8.4	15.0	21.6	41.3	65.4	95.0	172	------	396
0000	A and B	30	3.1	6.0	10.4	29.3	53.4	83.5	165	------	395
		60	6.5	12.0	19.1	39.4	62.4	92.9	175	------	403
		90	13.2	19.5	27.0	48.0	74.4	102.0	183	------	413
	C	30	2.2	3.6	6.1	14.9	31.8	57.6	125	------	312
		60	3.6	6.3	10.4	24.9	43.8	70.5	137	------	324
		90	7.9	12.0	19.1	35.0	55.2	81.4	148	------	335

Table 56.—Sags for Bare Stranded Aluminum—Continued

MEDIUM LOADING DISTRICT

[Sags being such that when loaded at 15° F. the conductor will be stressed to 50 per cent of its ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—								
			100	125	150	200	250	300	400	500	600
		°F.									
1	A and B	30	2.6	5.4	10.4	------	------	------	------	------	------
		60	5.3	10.5	18.7	------	------	------	------	------	------
		90	11.3	18.6	27.4	------	------	------	------	------	------
	C	30	1.7	3.3	5.4	------	------	------	------	------	------
		60	2.9	5.4	9.4	------	------	------	------	------	------
		90	6.0	11.1	17.3	------	------	------	------	------	------
0	A and B	30	2.4	4.5	7.5	22.6	46.8	76.3	156	257	380
		60	4.3	8.1	14.0	33.1	57.6	90.7	165	265	392
		90	9.6	15.6	23.0	42.7	66.6	96.5	176	275	400
	C	30	1.9	3.0	4.7	11.0	24.6	47.5	113	196	297
		60	2.6	4.5	7.6	18.7	42.6	61.2	122	208	310
		90	5.0	8.7	14.0	29.3	49.2	73.4	138	220	321
00	A and B	30	2.2	3.9	6.1	16.3	33.0	59.0	122	210	314
		60	3.8	6.9	11.2	25.9	46.2	71.3	134	222	325
		90	8.4	13.5	19.8	36.5	56.4	82.8	146	233	337
	C	30	1.4	2.7	4.0	9.1	18.0	33.1	84.5	155	243
		60	2.4	4.2	6.5	13.9	28.2	48.2	99.8	170	259
		90	4.6	7.5	11.9	23.5	40.8	61.2	114	185	272
000	A and B	30	2.2	3.6	5.8	13.0	25.8	46.8	99.8	173	263
		60	3.6	6.3	9.7	21.1	37.2	60.5	113	187	276
		90	7.9	12.3	18.0	32.2	49.8	72.7	127	199	288
	C	30	1.7	2.7	4.3	8.2	15.0	25.9	65.3	124	199
		60	2.6	3.9	6.5	12.9	22.8	38.9	82.6	140	214
		90	4.6	7.2	10.8	21.6	34.8	52.6	97.9	156	232
0000	A and B	30	2.2	3.6	5.4	11.5	20.4	38.2	80.6	142	217
		60	3.4	6.0	9.0	19.2	31.8	51.8	96.0	158	233
		90	7.2	11.4	16.2	29.8	44.4	64.1	110	173	248
	C	30	1.4	2.7	4.3	7.2	13.8	22.3	50.9	101	160
		60	2.4	3.9	5.8	11.5	20.4	33.1	67.2	119	178
		90	4.3	6.9	10.4	19.2	31.8	46.8	84.5	137	199

Table 56.—Sags for Bare Stranded Aluminum—Continued

LIGHT LOADING DISTRICT

[Sags being such that when loaded at 30° F. the conductor will be stressed to 50 per cent of its ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of —								
			100	125	150	200	250	300	400	500	600
		°F.									
1	A and B	30	1.7	2.7	4.3	------	------	------	------	------	------
		60	2.6	4.5	6.8	------	------	------	------	------	------
		90	5.0	8.1	12.6	------	------	------	------	------	------
	C	30	1.4	2.4	3.6	------	------	------	------	------	------
		60	1.9	3.0	4.7	------	------	------	------	------	------
		90	3.1	5.1	7.6	------	------	------	------	------	------
0	A and B	30	1.9	2.7	4.0	8.2	15.6	27.4	65.3	120	193
		60	2.9	4.2	6.5	13.0	22.2	38.9	82.6	138	210
		90	4.8	7.8	11.9	21.1	36.0	52.6	97.0	161	226
	C	30	1.7	2.4	3.2	6.2	11.4	17.3	40.3	81.6	141
		60	1.9	3.3	5.0	9.1	15.6	24.5	55.7	101	161
		90	2.9	4.8	7.9	14.4	23.4	36.7	72.0	120	180
00	A and B	30	1.7	2.7	4.0	8.2	13.8	23.8	55.7	103	166
		60	2.6	4.2	6.5	12.5	21.0	35.3	72.0	122	184
		90	4.8	7.5	11.2	20.2	32.4	49.0	89.3	139	203
	C	30	1.4	2.1	3.2	6.2	10.8	16.6	35.5	67.2	115
		60	1.9	3.0	4.7	8.6	14.4	23.0	49.0	88.8	138
		90	3.1	4.8	7.2	13.9	22.2	33.8	65.3	108	158
000	A and B	30	1.7	2.7	4.3	7.7	12.6	21.6	46.1	91.2	144
		60	2.6	3.9	6.1	11.0	19.8	31.0	62.4	109	164
		90	4.8	7.2	10.8	19.7	30.6	44.6	79.7	127	186
	C	30	1.4	2.4	3.2	6.2	9.6	15.1	30.7	58.8	97
		60	1.9	3.0	4.3	8.2	13.8	20.9	43.2	78.0	119
		90	3.1	4.8	7.2	13.0	21.0	31.0	58.6	97.2	143
0000	A and B	30	1.4	2.7	4.0	7.2	12.0	20.2	42.2	79.2	128
		60	2.4	3.9	6.1	11.0	18.6	28.8	58.6	98.4	150
		90	4.6	7.2	10.4	18.2	28.8	41.8	74.9	118	168
	C	30	1.2	2.1	3.2	6.2	9.6	15.1	29.8	54.0	89
		60	1.9	3.0	4.3	7.7	13.2	20.9	40.3	69.6	109
		90	2.9	4.8	6.8	12.5	20.4	30.2	54.7	88.8	132

Table 57.—Sags for Bare Stranded Aluminum, Steel-Reinforced

HEAVY LOADING DISTRICT

[Sags being such that when loaded at 0° F. the cable will be stressed to 50 per cent of its ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags in (inches) for span lengths (in feet) of—							
			100	150	200	300	400	500	700	1,000
		°F.								
4	A and B	30	3.0	24.0	61.2	164.0	312	511		
		60	5.6	30.6	66.4	169.0	316	515		
		90	10.7	36.0	71.2	173.0	321	520		
	C	30	1.6	7.6	35.6	123.0	244	405		
		60	2.2	12.8	43.3	129.0	250	410		
		90	3.5	20.0	50.0	135.0	255	415		
2	A and B	30	1.9	6.9	25.4	95.3	192	319		
		60	2.7	11.4	34.0	103.0	199	325		
		90	4.7	18.4	41.8	110.0	206	332		
	C	30	1.3	3.7	9.7	58.9	141	245	555	
		60	1.7	5.1	14.6	69.3	150	254	562	
		90	2.3	7.6	22.4	78.7	158	262	570	
1	A and B	30	1.8	5.3	15.2	70.7	151	255	540	1,193
		60	2.5	8.0	23.2	79.6	159	263	548	1,200
		90	3.9	13.5	32.0	88.1	168	271	556	1,207
	C	30	1.3	3.3	7.4	36.5	103	190	424	944
		60	1.6	4.4	10.4	48.0	114	201	434	953
		90	2.2	6.3	15.6	59.2	125	211	443	962
0	A and B	30	1.6	4.5	10.5	48.6	115	202	435	954
		60	2.2	6.4	16.0	59.8	126	212	444	963
		90	3.5	10.4	24.2	70.0	136	221	454	972
	C	30	1.2	3.1	6.3	23.0	70.8	143	336	757
		60	1.5	4.0	8.3	32.1	84.5	156	348	768
		90	2.1	5.5	12.1	43.4	97.3	168	360	779
00	A and B	30	1.6	4.0	8.4	32.7	85.5	157	350	772
		60	2.0	5.4	12.4	44.0	98.2	169	362	783
		90	3.2	8.6	18.9	55.5	110	181	373	794
	C	30	1.3	2.9	5.6	17.0	47.0	103	262	607
		60	1.5	3.6	7.3	23.2	60.6	118	277	620
		90	2.0	5.0	10.1	32.4	74.7	133	291	634
000	A and B	30	1.3	3.9	7.7	24.1	63.2	122	284	636
		60	1.8	5.3	10.3	33.8	77.3	137	298	649
		90	3.0	8.0	15.9	45.2	90.5	150	311	662
	C	30	1.2	2.6	5.3	14.4	34.6	74.4	206	496
		60	1.4	3.5	6.6	18.9	45.7	90.7	223	512
		90	2.0	4.7	9.2	26.5	59.2	107	240	528
0000	A and B	30	1.5	3.7	6.6	19.4	47.0	93	230	524
		60	2.0	4.6	9.2	27.1	60.0	109	245	539
		90	2.8	7.0	14.1	37.6	74.9	125	260	554
	C	30	1.2	2.7	5.1	13.0	27.8	55.1	157	399
		60	1.5	3.5	6.4	16.7	36.1	69.8	177	418
		90	1.9	4.5	8.6	22.6	47.8	85.9	196	437

Table 57.—Sags for Bare Stranded Aluminum, Steel-Reinforced—Continued

MEDIUM LOADING DISTRICT

[Sags being such that when loaded at 15° F. the cable will be stressed to 50 per cent of the ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of— 100	150	200	300	400	500	700	1,000
		°F.								
4	A and B	30	1.5	4.3	11.5	62.2	142	250	------	------
		60	2.0	6.1	17.8	72.3	151	252	------	------
		90	2.9	9.9	26.5	81.4	159	261	------	------
	C	30	1.1	2.9	6.3	28.9	92.8	179	------	------
		60	1.4	3.7	8.3	39.7	105	190	------	------
		90	1.8	5.0	12.1	51.3	116	200	------	------
2	A and B	30	1.3	3.4	7.1	26.1	75.2	145	------	------
		60	1.6	4.5	9.7	36.4	88.6	158	------	------
		90	2.2	6.6	14.6	48.0	101	170	------	------
	C	30	1.1	2.6	5.0	14.5	38.7	90	------	------
		60	1.3	3.2	6.2	19.0	50.9	106	------	------
		90	1.7	4.2	8.3	26.3	65.0	122	------	------
1	A and B	30	1.4	3.3	6.4	20.1	54.1	111	270	616
		60	1.7	4.3	8.6	27.8	68.2	126	285	629
		90	2.5	6.1	12.6	38.4	82.0	140	298	642
	C	30	1.1	2.6	4.8	12.7	29.5	63.9	190	475
		60	1.3	3.1	6.0	16.3	38.5	79.6	209	492
		90	1.7	4.0	7.7	21.9	50.7	96.1	226	509
0	A and B	30	1.4	3.2	6.0	16.6	40.2	83.2	216	505
		60	1.7	4.2	7.9	22.7	52.7	99.6	232	522
		90	2.4	5.8	11.3	31.7	66.8	115	248	537
	C	30	1.0	2.5	4.6	11.7	24.4	48.0	144	382
		60	1.3	3.0	5.7	14.5	31.3	61.0	163	402
		90	1.7	3.9	7.3	19.2	41.2	76.5	182	421
00	A and B	30	1.3	3.1	5.7	14.8	32.5	63.8	171	416
		60	1.7	4.0	7.5	19.7	42.8	79.6	190	435
		90	2.3	5.5	10.4	27.3	55.8	96.1	208	453
	C	30	1.0	2.4	4.4	10.9	21.7	39.6	110	305
		60	1.3	3.0	5.5	13.5	27.2	49.9	131	329
		90	1.7	3.8	7.0	17.5	35.4	63.3	151	351
000	A and B	30	1.3	3.0	5.6	13.9	28.4	52.3	138	346
		60	1.7	3.9	7.1	18.0	37.0	66.7	159	368
		90	2.3	5.4	10.0	24.8	48.8	82.7	178	388
	C	30	1.0	2.5	4.4	10.5	20.2	35.0	89	248
		60	1.3	3.0	5.3	12.9	25.0	43.7	108	273
		90	1.7	4.0	6.9	16.6	32.2	55.4	128	298
0000	A and B	30	1.3	3.0	5.4	13.0	25.8	45.5	114	289
		60	1.6	3.8	6.9	16.9	33.2	57.8	134	313
		90	2.3	5.2	9.6	23.0	43.8	72.8	155	336
	C	30	1.0	2.4	4.3	10.2	19.2	32.3	71.8	203
		60	1.3	2.9	5.3	12.5	23.5	39.7	86.8	229
		90	1.6	3.7	6.8	15.9	30.0	50.0	105	255

Table 57.—Sags for Bare Stranded Aluminum, Steel-Reinforced—Continued

LIGHT LOADING DISTRICT

[Sags being such that when loaded to 30° F. the cable will be stressed to 50 per cent of the ultimate strength for grades A and B, and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Sags (in inches) for span lengths (in feet) of—							
			100	150	200	300	400	500	700	1,000
		°F.								
4	A and B	30	1.2	2.8	5.2	13.8	31.5	65.6	------	------
		60	1.5	3.5	6.7	18.0	41.5	81.7	------	------
		90	2.0	4.7	9.0	25.2	54.3	98.0	------	------
	C	30	1.0	2.3	4.1	10.1	20.6	38.9	------	------
		60	1.2	2.7	5.0	12.4	25.8	48.9	------	------
		90	1.5	3.4	6.2	16.0	33.3	62.0	------	------
2	A and B	30	1.2	2.7	5.0	12.3	25.3	47.0	------	------
		60	1.5	3.4	6.2	15.7	32.3	59.7	------	------
		90	1.9	4.5	8.3	20.9	42.6	75.0	------	------
	C	30	1.0	2.2	4.0	9.5	18.4	31.8	------	------
		60	1.2	2.7	4.9	11.5	22.3	39.1	------	------
		90	1.5	3.3	6.0	14.4	28.2	49.2	------	------
1	A and B	30	1.2	2.7	4.9	12.0	23.9	42.7	113	298
		60	1.5	3.4	6.2	15.2	30.4	54.0	133	322
		90	2.0	4.5	8.2	20.2	39.8	68.4	153	344
	C	30	1.0	2.2	4.0	9.5	17.9	30.3	73.4	206
		60	1.2	2.7	4.8	11.4	21.7	36.9	88.7	232
		90	1.5	3.3	6.0	14.2	27.2	46.1	107	258
0	A and B	30	1.2	2.7	5.0	11.7	22.6	39.1	97.8	259
		60	1.5	3.3	6.0	14.7	28.4	49.2	117	284
		90	2.0	4.4	8.0	19.4	37.1	62.5	138	308
	C	30	1.0	2.2	4.0	9.3	17.3	28.9	66.4	178
		60	1.1	2.6	4.8	11.1	20.9	34.8	80.0	204
		90	1.4	3.3	5.9	13.9	26.0	43.4	97.0	230
00	A and B	30	1.2	2.7	4.9	11.3	21.5	36.5	86.9	226
		60	1.4	3.3	6.0	14.2	27.0	45.7	105	252
		90	2.0	4.4	7.9	18.6	35.0	57.9	125	277
	C	30	1.0	2.2	4.0	9.1	16.9	27.7	61.3	157
		60	1.1	2.6	4.8	10.9	20.2	33.2	73.7	181
		90	1.4	3.3	5.9	13.6	25.1	41.2	89.2	207
000	A and B	30	1.2	2.6	4.8	11.2	20.9	34.9	79.2	201
		60	1.4	3.3	5.9	13.9	26.1	43.2	96.3	227
		90	1.9	4.3	7.8	18.2	33.7	54.7	115	253
	C	30	1.0	2.2	3.9	8.8	16.7	26.9	58.2	142
		60	1.1	2.6	4.6	10.8	19.8	32.4	69.4	165
		90	1.4	3.3	5.8	13.5	24.5	39.8	84.0	190
0000	A and B	30	1.2	2.6	4.7	11.1	20.4	33.5	73.8	180
		60	1.5	3.3	5.9	13.7	25.2	41.3	89.3	206
		90	1.9	4.3	7.7	17.8	32.5	52.3	108	232
	C	30	1.0	2.2	3.9	8.8	16.4	26.3	55.7	131
		60	1.1	2.6	4.7	10.7	19.6	31.4	66.0	152
		90	1.4	3.2	5.8	13.3	24.0	38.6	79.7	176

Table 58.—Stringing Tensions for Medium and Hard-Drawn Bare Solid Copper Wire

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	168	76	46	------	------	------	------	------	------
		60	116	57	41	------	------	------	------	------	------
		90	77	48	38	------	------	------	------	------	------
6	A and B	30	268	152	97	------	------	------	------	------	------
		60	185	111	82	------	------	------	------	------	------
		90	124	87	72	------	------	------	------	------	------
	C	30	478	367	251	161	------	------	------	------	------
		60	385	277	183	128	------	------	------	------	------
		90	297	196	137	105	------	------	------	------	------
4	A and B	30	640	525	401	297	228	179	156	------	------
		60	496	391	293	233	192	163	148	------	------
		90	355	274	215	184	166	146	140	------	------
	C	30	891	823	721	614	502	320	240	------	------
		60	748	676	581	483	387	264	218	------	------
		90	597	535	447	359	300	228	197	------	------
2	A and B	30	1, 104	1, 023	911	791	678	496	412	339	313
		60	875	788	700	590	522	417	365	323	305
		90	639	577	511	449	409	349	331	311	295
	C	30	1, 448	1, 377	1, 305	1, 226	1, 122	896	700	496	417
		60	1, 216	1, 143	1, 080	997	903	723	584	454	397
		90	976	913	851	794	705	572	491	418	378
1	A and B	30	1, 379	1, 304	1, 205	1, 113	988	780	636	518	472
		60	1, 080	1, 008	944	852	754	622	544	481	455
		90	803	753	688	642	590	518	484	452	432
	C	30	1, 788	1, 742	1, 676	1, 575	1, 500	1, 277	1, 080	780	645
		60	1, 486	1, 435	1, 386	1, 290	1, 228	1, 035	878	684	602
		90	1, 191	1, 149	1, 100	1, 021	970	812	731	615	563
0	A and B	30	1, 732	1, 657	1, 566	1, 471	1, 350	1, 143	954	771	692
		60	1, 375	1, 276	1, 214	1, 131	1, 056	900	812	700	655
		90	1, 007	954	896	854	808	750	692	646	622
	C	30	2, 221	2, 171	2, 080	1, 994	1, 919	1, 740	1, 521	1, 168	979
		60	1, 848	1, 795	1, 699	1, 645	1, 566	1, 409	1, 243	1, 011	892
		90	1, 476	1, 434	1, 351	1, 302	1, 247	1, 135	1, 018	892	825
00	A and B	30	2, 128	2, 055	1, 982	1, 878	1, 763	1, 538	1, 366	1, 116	1, 001
		60	1, 654	1, 596	1, 549	1, 456	1, 382	1, 236	1, 142	996	934
		90	1, 215	1, 178	1, 142	1, 095	1, 058	1, 001	960	908	882
	C	30	2, 731	2, 670	2, 608	2, 513	2, 430	2, 231	2, 042	1, 669	1, 434
		60	2, 243	2, 198	2, 145	2, 066	1, 967	1, 827	1, 696	1, 420	1, 289
		90	1, 796	1, 743	1, 696	1, 639	1, 587	1, 456	1, 383	1, 242	1, 170
0000	A and B	30	3, 171	3, 107	3, 080	2, 948	2, 890	2, 658	2, 432	2, 168	1, 985
		60	2, 426	2, 392	2, 342	2, 292	2, 250	2, 083	2, 010	1, 885	1, 810
		90	1, 735	1, 718	1, 718	1, 726	1, 735	1, 694	1, 676	1, 694	1, 676
	C	30	4, 001	3, 960	3, 928	3, 850	3, 792	3, 593	3, 430	3, 053	2, 721
		60	3, 270	3, 238	3, 188	3, 129	3, 070	2, 948	2, 831	2, 581	2, 390
		90	2, 521	2, 514	2, 508	2, 456	2, 456	2, 322	2, 307	2, 215	2, 140

Table 58.—Stringing Tensions for Medium and Hard-Drawn Bare Solid Copper Wire—Continued

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	100	125	150	175	200	250	300	400	500	700	1,000
		°F.											
8	B	30	284	229	168	----	----	----	----	----	----	----	----
		60	225	175	124	----	----	----	----	----	----	----	----
		90	169	125	89	----	----	----	----	----	----	----	----
	C	30	395	357	307	----	----	----	----	----	----	----	----
		60	338	299	249	----	----	----	----	----	----	----	----
		90	277	242	194	----	----	----	----	----	----	----	----
6	A and B	30	513	470	418	363	----	----	----	----	----	----	----
		60	421	375	330	281	----	----	----	----	----	----	----
		90	327	291	247	212	----	----	----	----	----	----	----
	C	30	664	634	597	559	----	----	----	----	----	----	----
		60	571	542	504	468	----	----	----	----	----	----	----
		90	477	449	414	379	----	----	----	----	----	----	----
4	A and B	30	855	832	783	742	682	584	471	350	----	----	----
		60	708	685	639	595	546	468	386	314	----	----	----
		90	562	544	502	470	424	377	326	285	----	----	----
	C	30	1,065	1,050	1,018	983	949	874	770	562	----	----	----
		60	922	905	872	840	807	736	644	481	----	----	----
		90	768	755	729	702	672	608	533	411	----	----	----
2	A and B	30	1,344	1,330	1,274	1,230	1,195	1,101	984	794	674	574	----
		60	1,104	1,096	1,046	1,007	974	888	804	686	606	548	----
		90	877	869	825	796	770	721	661	595	561	527	----
	C	30	1,659	1,642	1,615	1,571	1,540	1,477	1,382	1,184	1,010	786	----
		60	1,420	1,407	1,383	1,342	1,310	1,253	1,161	997	877	731	----
		90	1,180	1,169	1,148	1,112	1,080	1,039	971	849	773	682	----
1	A and B	30	1,650	1,625	1,585	1,539	1,510	1,408	1,303	1,106	963	826	----
		60	1,343	1,333	1,283	1,254	1,228	1,155	1,080	940	858	773	----
		90	1,057	1,040	1,005	990	973	914	878	813	773	734	----
	C	30	2,022	2,012	1,975	1,942	1,922	1,840	1,755	1,588	1,398	1,126	----
		60	1,729	1,719	1,690	1,664	1,637	1,565	1,484	1,349	1,207	1,027	----
		90	1,434	1,428	1,392	1,375	1,359	1,296	1,245	1,133	1,060	956	----
0	A and B	30	2,013	1,997	1,935	1,915	1,890	1,798	1,700	1,483	1,335	1,152	----
		60	1,636	1,620	1,575	1,554	1,536	1,471	1,400	1,251	1,168	1,076	----
		90	1,268	1,260	1,226	1,223	1,223	1,165	1,148	1,081	1,056	1,020	----
	C	30	2,450	2,445	2,433	2,400	2,384	2,292	2,220	2,055	1,844	1,567	----
		60	2,089	2,072	2,060	2,022	2,028	1,961	1,878	1,754	1,608	1,430	----
		90	1,704	1,706	1,691	1,670	1,674	1,604	1,566	1,484	1,396	1,301	----
00	A and B	30	2,432	2,425	2,410	2,369	2,322	2,233	2,139	1,925	1,768	1,565	1,445
		60	1,961	1,966	1,946	1,925	1,878	1,816	1,768	1,633	1,555	1,460	1,387
		90	1,503	1,508	1,508	1,503	1,482	1,460	1,440	1,398	1,388	1,362	1,340
	C	30	3,015	3,000	2,982	2,960	2,928	2,860	2,760	2,592	2,420	2,102	1,852
		60	2,520	2,525	2,515	2,489	2,462	2,436	2,322	2,200	2,100	1,914	1,753
		90	2,070	2,070	2,060	2,050	2,019	1,997	1,940	1,873	1,816	1,732	1,658
0000	A and B	30	3,688	3,612	3,570	3,553	3,520	3,453	3,320	3,148	2,948	2,764	2,582
		60	2,930	2,855	2,840	2,821	2,821	2,780	2,757	2,663	2,590	2,549	2,472
		90	2,200	2,174	2,167	2,182	2,209	2,232	2,224	2,266	2,308	2,358	2,372
	C	30	4,460	4,427	4,400	4,360	4,332	4,319	4,200	4,100	3,920	3,593	3,230
		60	3,728	3,679	3,652	3,644	3,620	3,628	3,552	3,488	3,388	3,070	3,053
		90	2,948	2,940	2,930	2,922	2,930	2,972	2,930	2,972	2,948	2,930	2,872

Table 58.—Stringing Tensions for Medium and Hard-Drawn Bare Solid Copper Wire—Continued

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—										
			100	125	150	175	200	250	300	400	500	700	1, 000
		° F.											
8	B	30	405	399	395	-----	-----	-----	-----	-----	-----	-----	-----
		60	345	341	338	-----	-----	-----	-----	-----	-----	-----	-----
		90	287	282	281	-----	-----	-----	-----	-----	-----	-----	-----
	C	30	488	486	484	479	-----	-----	-----	-----	-----	-----	-----
		60	428	428	423	418	-----	-----	-----	-----	-----	-----	-----
		90	371	369	365	363	-----	-----	-----	-----	-----	-----	-----
6	A and B	30	628	622	618	612	600	-----	-----	-----	-----	-----	-----
		60	539	533	528	522	510	-----	-----	-----	-----	-----	-----
		90	443	438	437	434	421	-----	-----	-----	-----	-----	-----
	C	30	758	752	748	747	738	-----	-----	-----	-----	-----	-----
		60	662	658	656	653	646	-----	-----	-----	-----	-----	-----
		90	570	564	564	560	554	-----	-----	-----	-----	-----	-----
4	A and B	30	978	970	962	957	950	941	913	856	805	-----	-----
		60	835	830	820	815	805	796	780	738	701	-----	-----
		90	684	683	672	672	670	667	647	624	603	-----	-----
	C	30	1, 180	1, 175	1, 165	1, 157	1, 155	1, 142	1, 128	1, 089	1, 050	-----	-----
		60	1, 032	1, 025	1, 017	1, 005	1, 004	992	983	957	928	-----	-----
		90	877	882	871	861	860	856	845	829	803	-----	-----
2	A and B	30	1, 500	1, 492	1, 487	1, 480	1, 461	1, 440	1, 417	1, 357	1, 297	1, 187	-----
		60	1, 258	1, 255	1, 255	1, 240	1, 234	1, 229	1, 203	1, 169	1, 135	1, 073	-----
		90	1, 030	1, 023	1, 028	1, 020	1, 013	1, 010	1, 004	985	979	976	-----
	C	30	1, 795	1, 790	1, 783	1, 777	1, 777	1, 748	1, 740	1, 690	1, 644	1, 535	-----
		60	1, 557	1, 545	1, 545	1, 540	1, 540	1, 521	1, 513	1, 474	1, 443	1, 372	-----
		90	1, 328	1, 318	1, 313	1, 310	1, 310	1, 292	1, 286	1, 279	1, 260	1, 217	-----
1	A and B	30	1, 820	1, 820	1, 811	1, 800	1, 778	1, 769	1, 736	1, 684	1, 615	1, 496	1, 375
		60	1, 526	1, 523	1, 523	1, 506	1, 506	1, 504	1, 465	1, 445	1, 412	1, 343	1, 294
		90	1, 231	1, 231	1, 235	1, 231	1, 227	1, 231	1, 227	1, 225	1, 211	1, 218	1, 211
	C	30	2, 208	2, 192	2, 184	2, 178	2, 170	2, 154	2, 129	2, 086	2, 034	1, 910	1, 760
		60	1, 910	1, 890	1, 890	1, 883	1, 880	1, 883	1, 845	1, 827	1, 775	1, 713	1, 615
		90	1, 605	1, 595	1, 592	1, 589	1, 589	1, 599	1, 569	1, 566	1, 556	1, 526	1, 507
0	A and B	30	2, 245	2, 230	2, 218	2, 204	2, 204	2, 183	2, 147	2, 092	2, 010	1, 894	1, 756
		60	1, 878	1, 862	1, 854	1, 845	1, 854	1, 816	1, 811	1, 790	1, 750	1, 703	1, 650
		90	1, 487	1, 492	1, 492	1, 487	1, 496	1, 496	1, 500	1, 520	1, 512	1, 534	1, 546
	C	30	2, 690	2, 680	2, 672	2, 672	2, 651	2, 648	2, 622	2, 569	2, 514	2, 407	2, 230
		60	2, 317	2, 300	2, 296	2, 300	2, 283	2, 275	2, 270	2, 238	2, 192	2, 153	2, 051
		90	1, 940	1, 928	1, 928	1, 932	1, 928	1, 940	1, 932	1, 919	1, 915	1, 923	1, 898
00	A and B	30	2, 732	2, 702	2, 691	2, 681	2, 686	2, 665	2, 612	2, 592	2, 509	2, 389	2, 216
		60	2, 250	2, 230	2, 230	2, 230	2, 230	2, 233	2, 212	2, 191	2, 170	2, 140	2, 081
		90	1, 785	1, 770	1, 785	1, 790	1, 810	1, 822	1, 810	1, 867	1, 884	1, 946	1, 946
	C	30	3, 231	3, 270	3, 253	3, 243	3, 253	3, 230	3, 192	3, 145	3, 100	2, 972	2, 806
		60	2, 808	2, 800	2, 782	2, 780	2, 782	2, 780	2, 773	2, 718	2, 711	2, 643	2, 575
		90	2, 351	2, 335	2, 325	2, 320	2, 335	2, 335	2, 331	2, 346	2, 346	2, 372	2, 388
0000	A and B	30	4, 070	4, 043	4, 034	4, 010	3, 985	3, 960	3, 935	3, 895	3, 793	3, 652	3, 511
		60	3, 320	3, 311	3, 303	3, 295	3, 288	3, 279	3, 279	3, 338	3, 295	3, 295	3, 303
		90	2, 563	2, 571	2, 590	2, 598	2, 590	2, 656	2, 713	2, 780	2, 855	2, 980	3, 097
	C	30	4, 850	4, 800	4, 800	4, 790	4, 800	4, 818	4, 790	4, 740	4, 632	4, 550	4, 334
		60	4, 100	4, 085	4, 052	4, 060	4, 093	4, 070	4, 093	4, 100	4, 038	4, 052	3, 979
		90	3, 352	3, 343	3, 329	3, 343	3, 388	3, 402	3, 429	3, 479	3, 492	3, 629	3, 710

Table 59.—Stringing Tensions for Medium and Hard-Drawn Bare Stranded Copper Wire

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	650	538	400	230	176	------	------	------	------
		60	506	403	294	195	160	------	------	------	------
		90	368	288	218	170	147	------	------	------	------
	C	30	909	835	730	506	323	------	------	------	------
		60	765	692	589	390	269	------	------	------	------
		90	621	550	454	301	228	------	------	------	------
2	A and B	30	1,149	1,061	941	712	525	374	322	------	------
		60	915	832	728	546	432	343	312	------	------
		90	692	619	536	426	374	322	302	------	------
	C	30	1,508	1,440	1,368	1,175	957	604	432	------	------
		60	1,274	1,206	1,139	957	764	520	411	------	------
		90	1,040	978	910	759	614	458	395	------	------
1	A and B	30	1,439	1,360	1,195	1,030	772	574	482	449	------
		60	1,142	1,069	983	785	653	515	462	442	------
		90	858	799	726	614	541	475	442	429	------
	C	30	1,960	1,802	1,729	1,551	1,340	917	673	574	535
		60	1,564	1,505	1,432	1,267	1,010	779	627	554	528
		90	1,267	1,208	1,148	1,010	865	673	587	541	521
0	A and B	30	1,884	1,801	1,710	1,519	1,278	938	764	681	647
		60	1,511	1,436	1,353	1,204	1,013	805	714	664	639
		90	1,145	1,087	1,013	921	822	722	681	647	631
	C	30	2,407	2,349	2,274	2,117	1,926	1,519	1,096	896	805
		60	2,034	1,975	1,909	1,760	1,486	1,262	988	863	789
		90	1,660	1,610	1,544	1,419	1,287	1,013	905	830	772
00	A and B	30	2,352	2,258	2,195	1,985	1,775	1,386	1,124	998	935
		60	1,869	1,806	1,733	1,565	1,418	1,187	1,008	966	924
		90	1,418	1,365	1,323	1,197	1,145	1,019	966	935	914
	C	30	2,972	2,908	2,867	2,772	2,531	2,111	1,628	1,323	1,176
		60	2,489	2,436	2,394	2,300	2,100	1,743	1,449	1,250	1,145
		90	2,016	1,974	1,932	1,869	1,701	1,460	1,302	1,176	1,113
0000	A and B	30	3,752	3,685	3,602	3,420	3,220	2,805	2,407	2,125	1,942
		60	2,988	2,955	2,888	2,756	2,590	2,341	2,158	1,975	1,892
		90	2,258	2,241	2,224	2,141	2,058	1,992	1,942	1,876	1,859
	C	30	4,665	4,631	4,598	4,465	4,233	3,868	3,503	2,988	2,490
		60	3,918	3,884	3,851	3,735	3,552	3,270	2,905	2,722	2,374
		90	3,171	3,137	3,104	3,038	2,888	2,706	2,556	2,523	2,291

Table 59.—Stringing Tensions for Medium and Hard-Drawn Bare Stranded Copper Wire—Continued

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	866	821	790	691	570	378	------	------	------
		60	722	677	650	557	454	326	------	------	------
		90	578	534	512	438	390	288	------	------	------
	C	30	1,085	1,056	1,030	957	864	650	------	------	------
		60	938	910	883	816	726	544	------	------	------
		90	794	768	742	678	598	451	------	------	------
2	A and B	30	1,383	1,352	1,316	1,217	1,128	910	692	580	528
		60	1,149	1,113	1,087	998	926	738	624	551	520
		90	915	889	858	796	738	629	580	530	510
	C	30	1,700	1,685	1,659	1,586	1,513	1,323	1,040	796	681
		60	1,472	1,451	1,425	1,360	1,290	1,123	902	744	655
		90	1,232	1,217	1,193	1,131	1,074	946	796	692	640
1	A and B	30	1,709	1,670	1,637	1,558	1,452	1,261	983	838	759
		60	1,406	1,373	1,346	1,274	1,195	1,049	871	799	739
		90	1,115	1,082	1,063	1,016	950	878	785	746	719
	C	30	2,086	2,066	2,039	1,987	1,894	1,709	1,432	1,162	977
		60	1,789	1,769	1,749	1,696	1,617	1,459	1,241	1,049	937
		90	1,485	1,472	1,452	1,406	1,346	1,221	1,089	983	898
0	A and B	30	2,170	2,158	2,100	2,034	1,930	1,726	1,436	1,257	1,112
		60	1,793	1,776	1,735	1,677	1,594	1,444	1,270	1,145	1,071
		90	1,419	1,411	1,374	1,345	1,282	1,179	1,129	1,071	1,046
	C	30	2,656	2,639	2,598	2,565	2,473	2,324	2,042	1,702	1,444
		60	2,283	2,266	2,233	2,204	2,117	2,000	1,776	1,544	1,361
		90	1,909	1,892	1,859	1,838	1,768	1,681	1,536	1,403	1,299
00	A and B	30	2,672	2,667	2,625	2,541	2,457	2,247	1,953	1,717	1,586
		60	2,189	2,184	2,158	2,090	2,037	1,880	1,712	1,575	1,502
		90	1,727	1,722	1,701	1,670	1,638	1,565	1,523	1,470	1,449
	C	30	3,287	3,266	3,213	3,166	3,108	2,930	2,657	2,300	2,037
		60	2,804	2,788	2,751	2,709	2,646	2,520	2,310	2,079	1,911
		90	2,331	2,315	2,279	2,252	2,205	2,121	2,006	1,880	1,827
0000	A and B	30	4,183	4,158	4,117	4,067	4,001	3,768	3,511	3,204	2,955
		60	3,436	3,420	3,386	3,353	3,320	3,204	3,046	2,922	2,805
		90	2,689	2,681	2,673	2,673	2,673	2,673	2,673	2,673	2,673
	C	30	5,113	5,063	5,046	5,030	4,980	4,764	4,631	4,183	3,801
		60	4,366	4,334	4,316	4,299	4,266	4,100	3,951	3,768	3,519
		90	3,619	3,586	3,586	3,586	3,569	3,469	3,420	3,370	3,303

55862°—27——20

Table 59.—Stringing Tensions for Medium and Hard-Drawn Bare Stranded Copper Wire—Continued

LIGHT LOADING DISTRICT

[The tension being such that when loaded at 30° F. the wire will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size, A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	200	250	350	500	700	1,000
		°F.									
4	A and B	30	986	976	973	957	931	914	772	------	------
		60	842	835	832	816	794	741	669	------	------
		90	698	692	688	678	662	626	582	------	------
	C	30	1,194	1,184	1,181	1,173	1,152	1,104	1,030	------	------
		60	1,043	1,037	1,032	1,029	1,008	966	902	------	------
		90	899	893	890	883	869	832	787	------	------
2	A and B	30	1,537	1,534	1,521	1,503	1,477	1,417	1,310	1,160	------
		60	1,310	1,305	1,292	1,274	1,253	1,204	1,144	1,050	------
		90	1,071	1,066	1,061	1,050	1,040	1,019	988	946	------
	C	30	1,851	1,846	1,841	1,812	1,794	1,752	1,680	1,524	------
		60	1,612	1,607	1,599	1,570	1,562	1,534	1,477	1,362	------
		90	1,378	1,373	1,368	1,342	1,342	1,321	1,284	1,217	------
1	A and B	30	1,888	1,881	1,868	1,848	1,815	1,762	1,643	1,492	1,350
		60	1,591	1,584	1,577	1,558	1,535	1,495	1,429	1,343	1,274
		90	1,294	1,290	1,287	1,277	1,271	1,267	1,234	1,214	1,195
	C	30	2,270	2,264	2,254	2,231	2,218	2,158	2,072	1,921	1,736
		60	1,960	1,957	1,954	1,934	1,921	1,884	1,815	1,716	1,597
		90	1,667	1,663	1,660	1,643	1,637	1,620	1,584	1,538	1,485
0	A and B	30	2,390	2,374	2,370	2,349	2,320	2,258	2,129	1,975	1,801
		60	2,013	2,004	2,000	1,992	1,967	1,921	1,868	1,772	1,685
		90	1,635	1,631	1,631	1,631	1,631	1,631	1,619	1,602	1,594
	C	30	2,872	2,864	2,855	2,847	2,822	2,764	2,681	2,523	2,324
		60	2,494	2,482	2,478	2,473	2,449	2,415	2,357	2,258	2,150
		90	2,121	2,117	2,112	2,108	2,092	2,075	2,050	2,021	1,975
00	A and B	30	2,945	2,930	2,924	2,919	2,877	2,793	2,667	2,520	2,342
		60	2,462	2,457	2,452	2,447	2,426	2,378	2,326	2,263	2,184
		90	1,995	1,995	1,995	1,995	1,995	2,011	2,011	2,037	2,048
	C	30	3,528	3,518	3,512	3,507	3,497	3,423	3,339	3,192	2,982
		60	3,056	3,045	3,035	3,024	3,014	2,982	2,930	2,856	2,741
		90	2,573	2,573	2,573	2,573	2,573	2,557	2,557	2,557	2,520
0000	A and B	30	4,590	4,573	4,565	4,548	4,532	4,432	4,333	4,150	3,951
		60	3,843	3,835	3,826	3,818	3,810	3,777	3,760	3,702	3,677
		90	3,088	3,088	3,088	3,121	3,154	3,204	3,254	3,337	3,428
	C	30	5,528	5,503	5,486	5,461	5,445	5,395	5,279	5,146	4,930
		60	4,772	4,748	4,739	4,731	4,714	4,681	4,631	4,598	4,548
		90	4,034	4,017	4,000	4,000	4,000	4,009	4,034	4,117	4,175

Table 60.—Stringing Tensions for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size, A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	C	30	114	63	50	------	------	------	------
		60	86	57	47	------	------	------	------
		90	66	50	44	------	------	------	------
6	A and B	30	194	116	101	------	------	------	------
		60	138	100	85	------	------	------	------
		90	107	89	79	------	------	------	------
	C	30	408	272	169	132	------	------	------
		60	315	209	138	115	------	------	------
		90	240	158	119	107	------	------	------
4	A and B	30	554	411	301	225	195	------	------
		60	414	310	238	197	178	------	------
		90	301	231	195	174	168	------	------
	C	30	840	738	602	476	362	------	------
		60	692	592	481	375	300	------	------
		90	551	465	365	297	251	------	------
2	A and B	30	1,044	932	786	660	559	443	386
		60	810	716	592	517	459	402	355
		90	608	538	467	420	391	363	334
	C	30	1,391	1,318	1,198	1,093	978	739	590
		60	1,160	1,083	976	870	783	618	522
		90	928	875	776	694	629	522	470
1	A and B	30	1,327	1,217	1,090	964	845	678	586
		60	1,038	953	845	744	682	573	527
		90	773	694	642	600	557	511	485
	C	30	1,749	1,660	1,562	1,454	1,356	1,097	917
		60	1,454	1,363	1,294	1,198	1,087	888	780
		90	1,160	1,090	1,022	930	882	753	685
0	A and B	30	1,686	1,566	1,488	1,322	1,201	996	871
		60	1,325	1,230	1,148	1,053	974	858	767
		90	979	900	880	812	783	730	704
	C	30	2,180	2,098	1,990	1,920	1,807	1,575	1,334
		60	1,804	1,729	1,645	1,562	1,496	1,272	1,135
		90	1,438	1,372	1,293	1,256	1,185	1,077	978
00	A and B	30	2,108	1,977	1,883	1,754	1,657	1,404	1,252
		60	1,643	1,549	1,481	1,372	1,288	1,190	1,095
		90	1,221	1,132	1,116	1,064	1,064	1,001	970
	C	30	2,709	2,609	2,490	2,425	2,295	2,081	1,872
		60	2,228	2,139	2,060	1,977	1,899	1,727	1,550
		90	1,774	1,706	1,617	1,586	1,492	1,403	1,335
0000	A and B	30	3,130	3,021	2,957	2,858	2,715	2,508	2,309
		60	2,408	2,340	2,290	2,216	2,190	2,073	1,950
		90	1,751	1,717	1,735	1,735	1,726	1,701	1,710
	C	30	3,969	3,918	3,842	3,751	3,679	3,461	3,252
		60	3,238	3,187	3,120	3,052	3,029	2,847	2,680
		90	2,513	2,498	2,463	2,422	2,407	2,331	2,290

Table 60.—Stringing Tensions for Medium and Hard-Drawn T. B. W. P.[1] Solid Copper Wire—Continued

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B, and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—						
			100	125	150	175	200	250	300
		° F.							
8	B	30	232	182	133	-------	-------	-------	-------
		60	160	121	97	-------	-------	-------	-------
		90	111	94	79	-------	-------	-------	-------
	C	30	364	300	237	-------	-------	-------	-------
		60	305	243	188	-------	-------	-------	-------
		90	250	194	148	-------	-------	-------	-------
6	A and B	30	469	410	331	264	-------	-------	-------
		60	379	322	260	215	-------	-------	-------
		90	293	246	200	173	-------	-------	-------
	C	30	628	590	532	465	-------	-------	-------
		60	540	496	446	384	-------	-------	-------
		90	446	410	365	306	-------	-------	-------
4	A and B	30	820	766	703	641	571	-------	-------
		60	677	626	572	514	456	-------	-------
		90	533	492	440	406	372	-------	-------
	C	30	1, 043	1, 010	956	916	862	-------	-------
		60	892	864	809	771	718	-------	-------
		90	748	720	674	638	595	-------	-------
2	A and B	30	1, 315	1, 262	1, 208	1, 148	1, 085	950	841
		60	1, 078	1, 035	984	948	877	792	713
		90	856	812	788	742	713	648	616
	C	30	1, 628	1, 589	1, 552	1, 515	1, 453	1, 356	1, 225
		60	1, 388	1, 359	1, 323	1, 286	1, 240	1, 148	1, 048
		90	1, 161	1, 127	1, 094	1, 075	1, 025	958	877
1	A and B	30	1, 611	1, 552	1, 523	1, 465	1, 415	1, 278	1, 163
		60	1, 326	1, 271	1, 235	1, 195	1, 153	1, 051	960
		90	1, 031	996	984	941	921	862	839
	C	30	1, 981	1, 965	1, 938	1, 896	1, 844	1, 742	1, 638
		60	1, 694	1, 676	1, 651	1, 598	1, 576	1, 484	1, 385
		90	1, 405	1, 385	1, 365	1, 340	1, 291	1, 235	1, 173
0	A and B	30	1, 977	1, 944	1, 906	1, 853	1, 811	1, 671	1, 509
		60	1, 616	1, 592	1, 555	1, 517	1, 496	1, 389	1, 276
		90	1, 248	1, 244	1, 227	1, 194	1, 190	1, 135	1, 065
	C	30	2, 459	2, 425	2, 402	2, 354	2, 291	2, 218	2, 092
		60	2, 078	2, 051	2, 022	1, 990	1, 952	1, 866	1, 783
		90	1, 704	1, 691	1, 683	1, 654	1, 596	1, 563	1, 484
00	A and B	30	2, 405	2, 384	2, 352	2, 290	2, 242	2, 139	2, 030
		60	1, 946	1, 941	1, 910	1, 878	1, 826	1, 774	1, 701
		90	1, 497	1, 514	1, 492	1, 461	1, 445	1, 440	1, 440
	C	30	3, 011	2, 991	2, 950	2, 880	2, 830	2, 765	2, 671
		60	2, 537	2, 520	2, 472	2, 437	2, 400	2, 332	2, 280
		90	2, 089	2, 067	2, 034	1, 988	1, 956	1, 946	1, 920
0000	A and B	30	3, 601	3, 552	3, 544	3, 470	3, 460	3, 329	3, 252
		60	2, 870	2, 862	2, 830	2, 771	2, 789	2, 755	2, 689
		90	2, 158	2, 165	2, 165	2, 173	2, 232	2, 232	2, 300
	C	30	4, 415	4, 391	4, 359	4, 341	4, 300	4, 200	4, 118
		60	3, 693	3, 651	3, 651	3, 635	3, 585	3, 542	3, 452
		90	2, 954	2, 939	2, 930	2, 947	2, 961	2, 921	2, 930

Table 60.—Stringing Tensions for Medium and Hard-Drawn T. B. W. P. Solid Copper Wire—Continued

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—						
			100	125	150	175	200	250	300
		°F.							
8	B	30	378	359	336	--------	--------	--------	--------
		60	319	303	281	--------	--------	--------	--------
		90	261	248	230	--------	--------	--------	--------
	C	30	470	455	443	422	--------	--------	--------
		60	410	395	384	366	--------	--------	--------
		90	352	341	328	312	--------	--------	--------
6	A and B	30	634	584	562	539	512	--------	--------
		60	544	493	477	451	432	--------	--------
		90	449	405	387	373	352	--------	--------
	C	30	747	727	709	696	674	--------	--------
		60	649	633	618	605	584	--------	--------
		90	554	543	528	515	479	--------	--------
4	A and B	30	951	940	920	890	860	--------	--------
		60	799	790	776	757	722	--------	--------
		90	657	649	639	613	597	--------	--------
	C	30	1,157	1,144	1,133	1,122	1,091	--------	--------
		60	1,014	992	983	971	952	--------	--------
		90	864	847	839	831	805	--------	--------
2	A and B	30	1,476	1,460	1,435	1,425	1,383	1,331	1,284
		60	1,226	1,232	1,211	1,205	1,164	1,132	1,091
		90	1,007	1,001	987	982	966	929	924
	C	30	1,790	1,779	1,764	1,737	1,714	1,685	1,633
		60	1,545	1,534	1,529	1,513	1,495	1,466	1,424
		90	1,320	1,307	1,299	1,278	1,271	1,255	1,213
1	A and B	30	1,808	1,792	1,781	1,755	1,726	1,686	1,644
		60	1,513	1,500	1,496	1,473	1,441	1,434	1,382
		90	1,218	1,212	1,212	1,212	1,189	1,179	1,172
	C	30	2,188	2,170	2,145	2,038	2,118	2,070	2,040
		60	1,886	1,873	1,864	1,847	1,815	1,801	1,778
		90	1,592	1,585	1,572	1,562	1,559	1,526	1,526
0	A and B	30	2,230	2,198	2,185	2,163	2,152	2,098	2,052
		60	1,858	1,850	1,824	1,800	1,792	1,792	1,734
		90	1,497	1,485	1,476	1,485	1,494	1,476	1,468
	C	30	2,682	2,662	2,650	2,638	2,623	2,575	2,529
		60	2,297	2,297	2,280	2,277	2,269	2,230	2,198
		90	1,935	1,932	1,925	1,915	1,920	1,900	1,882
00	A and B	30	2,702	2,682	2,678	2,670	2,655	2,588	2,568
		60	2,229	2,219	2,211	2,208	2,232	2,180	2,165
		90	1,774	1,774	1,790	1,800	1,795	1,800	1,832
	C	30	3,271	3,267	3,232	3,232	3,209	3,171	3,140
		60	2,795	2,785	2,785	2,780	2,770	2,728	2,702
		90	2,335	2,331	2,314	2,336	2,310	2,310	2,314
0000	A and B	30	4,019	4,010	4,010	4,000	3,960	3,884	3,850
		60	3,288	3,270	3,295	3,303	3,260	3,245	3,303
		90	2,558	2,564	2,605	2,614	2,672	2,672	2,698
	C	30	4,830	4,708	4,708	4,780	4,798	4,740	4,690
		60	4,060	4,068	4,040	4,068	4,083	4,050	4,050
		90	3,343	3,320	3,338	3,370	3,402	3,387	3,379

Table 61.—Stringing Tensions for T. B. W. P. Solid Soft Copper Wire

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—				
			100	125	150	175	200
		°F.					
6	C	30	58	54	49		
		60	54	51	49		
		90	49	47	48		
4	A and B	30	109	98	91		
		60	96	90	88		
		90	88	85	81		
	C	30	171	137	121		
		60	138	121	112		
		90	116	109	103		
2	A and B	30	324	269	235	224	219
		60	248	224	209	209	206
		90	201	198	193	196	196
	C	30	543	433	349	308	287
		60	391	329	290	274	261
		90	276	266	253	248	248
1	A and B	30	491	416	367	334	324
		60	360	328	318	301	295
		90	278	282	285	278	275
	C	30	810	682	576	485	442
		60	580	507	449	416	393
		90	406	383	376	354	350
0	A and B	30	783	663	588	534	506
		60	551	497	485	456	456
		90	414	414	414	414	431
	C	30	1,156	1,024	892	787	713
		60	824	746	680	630	605
		90	592	568	551	538	526
00	A and B	30	1,080	991	898	798	757
		60	772	731	699	673	662
		90	548	574	584	579	584
	C	30	1,539	1,424	1,304	1,190	1,085
		60	1,120	1,043	976	944	887
		90	782	772	778	761	757
0000	A and B	30	2,001	1,876	1,768	1,634	1,618
		60	1,410	1,353	1,360	1,319	1,303
		90	1,020	1,020	1,062	1,070	1,136
	C	30	2,622	2,522	2,422	2,273	2,233
		60	1,942	1,868	1,817	1,776	1,726
		90	1,335	1,353	1,410	1,394	1,435

Table 61.—Stringing Tensions for T. B. W. P. Solid Soft Copper Wire—Continued

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—					
			100	125	150	175	200	250
		°F.						
6	C	30	190	134	111	-------	-------	-------
		60	137	111	100	-------	-------	-------
		90	106	96	91	-------	-------	-------
4	A and B	30	298	230	193	181	-------	-------
		60	212	183	168	161	-------	-------
		90	161	150	147	147	-------	-------
	C	30	461	388	309	267	-------	-------
		60	329	282	244	220	-------	-------
		90	235	218	196	196	-------	-------
2	A and B	30	663	590	519	449	423	-------
		60	483	438	407	375	360	-------
		90	336	334	329	318	318	-------
	C	30	906	820	756	689	611	-------
		60	678	618	572	530	496	-------
		90	491	462	446	433	417	-------
1	A and B	30	888	806	738	655	612	556
		60	632	579	570	537	518	488
		90	445	439	449	435	439	449
	C	30	1, 160	1, 107	1, 035	990	895	774
		60	885	838	803	753	702	662
		90	632	625	609	609	589	566
0	A and B	30	1, 172	1, 090	1, 031	954	912	804
		60	834	812	775	775	746	703
		90	601	596	613	613	618	622
	C	30	1, 508	1, 450	1, 384	1, 322	1, 251	1, 123
		60	1, 152	1, 110	1, 074	1, 040	995	958
		90	821	816	816	812	812	800
00	A and B	30	1, 518	1, 482	1, 393	1, 351	1, 278	1, 185
		60	1, 095	1, 080	1, 075	1, 033	1, 038	986
		90	772	804	819	850	845	871
	C	30	1, 930	1, 868	1, 836	1, 806	1, 696	1, 581
		60	1, 493	1, 461	1, 420	1, 403	1, 352	1, 320
		90	1, 069	1, 064	1, 085	1, 100	1, 080	1, 100
0000	A and B	30	2, 490	2, 458	2, 423	2, 315	2, 290	2, 165
		60	1, 826	1, 801	1, 801	1, 801	1, 809	1, 809
		90	1, 269	1, 320	1, 394	1, 403	1, 469	1, 527
	C	30	3, 112	3, 090	3, 030	2, 988	2, 988	2, 808
		60	2, 390	2, 408	2, 373	2, 341	2, 350	2, 291
		90	1, 717	1, 760	1, 777	1, 835	1, 892	1, 900

Table 61.—Stringing Tensions for T. B. W. P. Solid Soft Copper Wire—Continued

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of— 100	125	150	175	200	250
		° F.						
6	A and B	30	279	239	206	--------	--------	--------
		60	202	181	167	--------	--------	--------
		90	148	142	135	--------	--------	--------
	C	30	384	342	314	--------	--------	--------
		60	303	262	239	--------	--------	--------
		90	224	199	190	--------	--------	--------
4	A and B	30	514	469	434	381	346	--------
		60	383	347	334	311	290	--------
		90	269	266	258	248	241	--------
	C	30	648	619	594	554	508	--------
		60	508	491	463	438	404	--------
		90	381	362	355	342	332	--------
2	A and B	30	882	846	809	772	731	658
		60	663	650	619	600	584	558
		90	480	475	475	485	485	480
	C	30	1, 106	1, 078	1, 044	1, 010	969	904
		60	880	848	833	802	783	736
		90	653	647	640	624	629	619
1	A and B	30	1, 136	1, 081	1, 055	1, 028	983	894
		60	852	826	822	800	780	750
		90	608	609	619	619	638	622
	C	30	1, 375	1, 362	1, 340	1, 304	1, 267	1, 199
		60	1, 087	1, 087	1, 054	1, 035	1, 041	982
		90	813	819	816	816	813	813
0	A and B	30	1, 450	1, 409	1, 367	1, 359	1, 310	1, 214
		60	1, 090	1, 069	1, 069	1, 060	1, 027	1, 019
		90	783	787	808	812	842	871
	C	30	1, 745	1, 712	1, 707	1, 683	1, 637	1, 567
		60	1, 396	1, 360	1, 360	1, 355	1, 360	1, 277
		90	1, 040	1, 032	1, 056	1, 060	1, 056	1, 060
00	A and B	30	1, 830	1, 800	1, 778	1, 742	1, 721	1, 622
		60	1, 387	1, 366	1, 382	1, 387	1, 387	1, 345
		90	981	1, 012	1, 064	1, 064	1, 095	1, 121
	C	30	2, 211	2, 207	2, 180	2, 140	2, 150	2, 070
		60	1, 764	1, 757	1, 747	1, 711	1, 726	1, 706
		90	1, 315	1, 330	1, 352	1, 357	1, 394	1, 391
0000	A and B	30	2, 962	2, 952	2, 898	2, 862	2, 798	2, 771
		60	2, 281	2, 273	2, 232	2, 250	2, 265	2, 258
		90	1, 610	1, 676	1, 693	1, 760	1, 768	1, 867
	C	30	3, 538	3, 543	3, 520	3, 494	3, 452	3, 403
		60	2, 822	2, 848	2, 822	2, 839	2, 789	2, 807
		90	2, 090	2, 159	2, 159	2, 190	2, 232	2, 282

Table 62.—Stringing Tensions for Ordinary Grade Steel Wire

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 0° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	260	130	89	------	------	------	------	------	------
		60	165	99	79	------	------	------	------	------	------
		90	110	83	70	------	------	------	------	------	------
6	A and B	30	320	190	135	------	------	------	------	------	------
		60	200	140	120	------	------	------	------	------	------
		90	135	115	105	------	------	------	------	------	------
	C	30	580	450	300	210	170	140	125	115	110
		60	430	300	220	170	150	130	120	110	110
		90	280	210	160	145	130	125	115	110	110
4	A and B	30	640	480	360	280	240	200	185	175	165
		60	430	330	260	230	210	185	180	170	165
		90	270	230	210	195	185	175	170	165	165
	C	30	970	850	710	560	450	310	260	220	210
		60	740	630	510	410	340	270	240	220	210
		90	530	440	360	310	280	240	220	210	200

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 15° F. the wire will be stressed to 50 per cent of ultimate strength for Grades A and B, and to 60 per cent for grade C]

8	C	30	580	520	450	------	------	------	------	------	------
		60	460	400	340	------	------	------	------	------	------
		90	340	300	240	------	------	------	------	------	------
6	A and B	30	670	610	530	------	------	------	------	------	------
		60	500	450	380	------	------	------	------	------	------
		90	360	310	270	------	------	------	------	------	------
	C	30	880	830	780	710	640	500	380	280	230
		60	710	660	610	550	490	390	320	260	220
		90	550	500	460	410	370	310	270	230	210
4	A and B	30	980	930	870	790	720	590	480	370	340
		60	760	710	650	600	540	460	400	340	320
		90	550	510	470	430	410	370	340	310	300
	C	30	1,250	1,220	1,170	1,110	1,050	920	780	550	480
		60	1,030	990	950	890	840	730	630	480	440
		90	800	770	730	680	640	570	510	420	400

Table 62.—Stringing Tensions for Ordinary Grade Steel Wire—Continued

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 30° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
8	C	30	730	720	710	------	------	------	------	------	------
		60	610	610	600	------	------	------	------	------	------
		90	490	490	480	------	------	------	------	------	------
6	A and B	30	850	840	830	------	------	------	------	------	------
		60	680	670	660	------	------	------	------	------	------
		90	520	520	510	------	------	------	------	------	------
	C	30	1,030	1,030	1,020	1,010	1,000	970	940	870	800
		60	870	860	850	850	840	820	790	730	680
		90	700	690	690	680	680	660	640	610	580
4	A and B	30	1,180	1,170	1,160	1,150	1,140	1,110	1,070	970	860
		60	950	940	930	920	910	890	860	810	760
		90	720	720	720	720	710	700	690	680	660
	C	30	1,420	1,420	1,410	1,400	1,390	1,370	1,340	1,260	1,180
		60	1,190	1,190	1,180	1,170	1,170	1,150	1,120	1,060	1,010
		90	970	960	960	950	950	930	910	880	860

Table 63.—Stringing Tensions for Siemens-Martin Steel Wire

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F., without load, the tensions being such that when loaded at 0 °F., the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of— 200	250	300	400	500	600	700	1,000
		°F.								
6	C	30	440	260	200	160	150	145	140	------
		60	330	220	185	155	150	145	140	------
		90	250	190	170	150	145	140	140	------
4	A and B	30	530	350	280	240	220	210	210	------
		60	400	290	260	230	220	210	210	------
		90	310	260	240	220	210	210	200	------
	C	30	1,000	730	520	340	300	270	270	260
		60	780	570	420	320	290	270	260	260
		90	590	440	360	300	280	260	260	260

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F., without load, the tensions being such that when loaded at 15° F., the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

6	C	30	1,010	890	760	520	390	330	300	270
		60	820	730	620	440	350	310	290	270
		90	690	580	490	380	320	300	280	260
4	A and B	30	1,130	1,020	860	640	520	450	430	390
		60	910	810	690	550	470	430	410	380
		90	700	640	560	470	430	400	390	370
	C	30	1,500	1,410	1,300	1,060	830	670	590	490
		60	1,280	1,180	1,090	880	720	610	550	480
		90	1,060	970	890	730	620	550	520	470

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F., without load, the tensions being such that when loaded at 30° F., the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

6	C	30	1,280	1,260	1,240	1,190	1,130	1,060	1,000	830
		60	1,110	1,090	1,080	1,030	980	920	880	760
		90	940	930	920	880	840	800	770	700
4	A and B	30	1,450	1,430	1,400	1,330	1,260	1,180	1,110	960
		60	1,230	1,210	1,180	1,130	1,080	1,020	980	890
		90	1,000	990	980	950	920	890	870	830
	C	30	1,770	1,750	1,730	1,680	1,620	1,540	1,480	1,280
		60	1,540	1,530	1,510	1,460	1,410	1,350	1,300	1,160
		90	1,310	1,300	1,290	1,260	1,220	1,170	1,140	1,060

Table 54.—Stringing Tensions for High-Tension Steel Wire

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F., without load, the tensions being such that when loaded at 0° F., the wire will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of— 200	250	300	400	500	600	700	1,000
		°F.								
6	C	30	1,730	1,590	1,420	960	560	400	330	250
		60	1,570	1,430	1,260	810	480	380	320	250
		90	1,400	1,260	1,100	680	420	350	300	250
4	A and B	30	1,970	1,800	1,590	1,110	710	540	470	390
		60	1,730	1,570	1,370	930	620	500	440	380
		90	1,500	1,340	1,160	770	550	460	420	370
	C	30	2,560	2,430	2,280	1,940	1,500	1,070	790	520
		60	2,330	2,190	2,050	1,720	1,290	930	710	500
		90	2,100	1,960	1,820	1,500	1,110	820	650	490

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 15° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	200	250	300	400	500	600	700	1,000
6	C	30	2,000	1,970	1,920	1,790	1,640	1,440	1,220	740
		60	1,820	1,800	1,750	1,620	1,480	1,290	1,090	690
		90	1,660	1,630	1,580	1,460	1,320	1,140	960	630
4	A and B	30	2,290	2,240	2,180	2,020	1,830	1,620	1,400	950
		60	2,060	2,010	1,950	1,800	1,620	1,430	1,230	880
		90	1,830	1,780	1,720	1,580	1,420	1,250	1,080	820
	C	30	2,810	2,770	2,730	2,620	2,480	2,320	2,140	1,540
		60	2,580	2,540	2,500	2,400	2,250	2,100	1,930	1,390
		90	2,350	2,310	2,270	2,170	2,030	1,880	1,730	1,260

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 30° F. the wire will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Steel wire gage No.	Grade of construction	Temperature	200	250	300	400	500	600	700	1,000
6	C	30	2,160	2,150	2,140	2,120	2,100	2,080	2,060	1,910
		60	1,980	1,980	1,970	1,950	1,930	1,910	1,890	1,750
		90	1,820	1,820	1,810	1,800	1,770	1,750	1,720	1,610
4	A and B	30	2,470	2,470	2,450	2,430	2,400	2,350	2,310	2,130
		60	2,240	2,230	2,220	2,200	2,180	2,140	2,090	1,940
		90	2,020	2,010	1,990	1,970	1,950	1,910	1,870	1,770
	C	30	2,980	2,970	2,960	2,940	2,920	2,890	2,860	2,730
		60	2,750	2,740	2,730	2,710	2,690	2,660	2,640	2,520
		90	2,530	2,520	2,510	2,490	2,470	2,440	2,420	2,320

Table 65.—Stringing Tensions for Ordinary Grade Steel Cable

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 0° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
1/4	A and B	30	470	320	220	170	150	130	125	120	115
		60	340	230	175	150	140	125	125	115	115
		90	230	175	150	135	130	120	120	115	115
	C	30	770	630	480	350	260	195	170	150	145
		60	610	500	370	270	220	180	160	150	140
		90	470	360	270	220	190	165	155	145	135
5/16	A and B	30	1,140	1,010	880	740	610	450	390	340	330
		60	900	780	670	560	490	400	360	330	320
		90	670	580	500	450	410	360	340	320	320
	C	30	1,550	1,440	1,330	1,210	1,090	820	620	480	420
		60	1,290	1,190	1,100	990	880	680	550	450	410
		90	1,040	960	870	780	690	550	480	420	390
3/8	A and B	30	1,680	1,580	1,460	1,320	1,180	920	780	640	580
		60	1,350	1,260	1,150	1,040	930	770	690	600	560
		90	1,020	950	870	800	740	660	620	560	540
	C	30	2,200	2,130	2,030	1,920	1,800	1,530	1,280	940	800
		60	1,850	1,780	1,690	1,590	1,480	1,260	1,070	840	760
		90	1,510	1,460	1,370	1,280	1,170	1,020	910	770	710
7/16	A and B	30	2,570	2,480	2,370	2,260	2,140	1,870	1,630	1,320	1,180
		60	2,080	2,000	1,900	1,810	1,710	1,530	1,370	1,180	1,110
		90	1,600	1,540	1,480	1,420	1,360	1,250	1,170	1,080	1,050
	C	30	3,280	3,210	3,130	3,040	2,940	2,700	2,450	1,990	1,690
		60	2,780	2,710	2,640	2,560	2,470	2,250	2,060	1,730	1,520
		90	2,280	2,220	2,160	2,100	2,020	1,860	1,720	1,510	1,390
1/2	A and B	30	3,120	3,020	2,930	2,830	2,720	2,470	2,200	1,790	1,600
		60	2,520	2,460	2,380	2,290	2,180	1,980	1,840	1,590	1,480
		90	1,940	1,910	1,860	1,800	1,730	1,630	1,550	1,420	1,380
	C	30	3,970	3,900	3,830	3,740	3,640	3,420	3,180	2,720	2,320
		60	3,380	3,300	3,230	3,150	3,070	2,880	2,670	2,330	2,060
		90	2,780	2,720	2,660	2,590	2,520	2,330	2,240	2,030	1,860
9/16	A and B	30	4,210	4,150	4,070	3,960	3,840	3,600	3,380	2,930	2,620
		60	3,440	3,380	3,300	3,230	3,150	2,960	2,800	2,560	2,380
		90	2,670	2,630	2,580	2,530	2,480	2,410	2,350	2,260	2,180
	C	30	5,310	5,280	5,230	5,140	5,050	4,840	4,590	4,140	3,720
		60	4,500	4,470	4,420	4,350	4,280	4,100	3,900	3,560	3,290
		90	3,700	3,680	3,650	3,600	3,540	3,400	3,270	3,080	2,920
5/8	A and B	30	5,250	5,160	5,070	4,980	4,880	4,660	4,390	3,960	3,590
		60	4,280	4,190	4,140	4,060	3,990	3,830	3,680	3,440	3,240
		90	3,340	3,290	3,250	3,220	3,180	3,140	3,080	2,980	2,930
	C	30	6,550	6,500	6,440	6,370	6,280	6,100	5,860	5,410	4,970
		60	5,570	5,530	5,480	5,410	5,340	5,190	4,980	4,660	4,380
		90	4,560	4,540	4,500	4,470	4,430	4,310	4,210	4,030	3,880

Table 65.—Stringing Tensions for Ordinary Grade Steel Cable—Con.

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 15° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
1/4	A and B	30	770	710	640	570	500	370	300	250	230
		60	630	570	510	450	390	310	260	230	220
		90	480	440	390	350	310	270	240	220	210
	C	30	990	950	900	840	780	640	520	360	300
		60	850	800	760	700	650	530	440	330	280
		90	700	660	620	570	520	430	370	300	270
5/16	A and B	30	1,420	1,380	1,330	1,290	1,220	1,090	950	750	650
		60	1,180	1,140	1,100	1,040	990	880	800	670	600
		90	930	900	870	830	790	720	670	590	560
	C	30	1,790	1,760	1,730	1,690	1,640	1,520	1,390	1,150	950
		60	1,540	1,500	1,470	1,440	1,400	1,290	1,190	990	850
		90	1,320	1,270	1,230	1,190	1,150	1,070	990	850	770
3/8	A and B	30	2,000	1,960	1,910	1,860	1,810	1,690	1,550	1,320	1,150
		60	1,640	1,610	1,580	1,550	1,510	1,410	1,300	1,140	1,040
		90	1,310	1,290	1,260	1,230	1,200	1,140	1,080	1,010	950
	C	30	2,470	2,440	2,420	2,380	2,340	2,240	2,120	1,860	1,640
		60	2,120	2,100	2,070	2,040	2,000	1,910	1,810	1,610	1,460
		90	1,780	1,760	1,740	1,710	1,670	1,610	1,520	1,390	1,280
7/16	A and B	30	2,940	2,890	2,860	2,830	2,780	2,660	2,540	2,320	2,090
		60	2,430	2,400	2,370	2,330	2,300	2,220	2,140	1,990	1,840
		90	1,940	1,920	1,890	1,870	1,860	1,820	1,780	1,720	1,660
	C	30	3,600	3,580	3,560	3,530	3,490	3,400	3,310	3,080	2,830
		60	3,100	3,080	3,060	3,030	3,000	2,930	2,840	2,670	2,500
		90	2,600	2,580	2,560	2,540	2,520	2,470	2,410	2,310	2,190
1/2	A and B	30	3,520	3,500	3,460	3,420	3,380	3,260	3,140	2,900	2,660
		60	2,920	2,900	2,860	2,830	2,800	2,740	2,640	2,500	2,370
		90	2,330	2,320	2,300	2,290	2,270	2,230	2,200	2,160	2,110
	C	30	4,310	4,300	4,290	4,260	4,220	4,130	4,050	3,800	3,560
		60	3,720	3,710	3,700	3,670	3,630	3,560	3,480	3,300	3,120
		90	3,120	3,110	3,100	3,080	3,060	3,010	2,950	2,850	2,750
9/16	A and B	30	4,720	4,700	4,670	4,630	4,580	4,470	4,360	4,110	3,900
		60	3,940	3,920	3,880	3,850	3,820	3,760	3,690	3,540	3,440
		90	3,160	3,150	3,140	3,130	3,120	3,100	3,080	3,060	3,040
	C	30	5,800	5,770	5,740	5,710	5,690	5,610	5,510	5,310	5,110
		60	5,000	4,970	4,940	4,920	4,900	4,850	4,790	4,630	4,470
		90	4,190	4,180	4,160	4,150	4,140	4,100	4,060	3,980	3,920
5/8	A and B	30	5,800	5,770	5,740	5,710	5,670	5,560	5,440	5,220	4,970
		60	4,830	4,800	4,780	4,750	4,730	4,670	4,620	4,540	4,400
		90	3,880	3,860	3,860	3,870	3,880	3,880	3,880	3,890	3,890
	C	30	7,110	7,070	7,050	7,030	7,000	6,940	6,870	6,680	6,400
		60	6,110	6,100	6,090	6,080	6,060	6,000	5,940	5,790	5,600
		90	5,110	5,110	5,110	5,110	5,110	5,110	5,070	5,000	4,940

Table 65.—Stringing Tensions for Ordinary Grade Steel Cable—Con.

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 30° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	175	200	250	300	400	500
		°F.									
¼	A and B	30	930	920	900	890	870	820	770	690	610
		60	790	770	760	740	720	690	660	590	540
		90	640	620	620	600	590	570	540	510	480
	C	30	1,160	1,140	1,120	1,100	1,080	1,050	1,010	930	850
		60	970	960	950	940	930	900	870	800	740
		90	820	810	800	790	780	760	730	690	640
5/16	A and B	30	1,620	1,610	1,600	1,580	1,550	1,520	1,470	1,380	1,290
		60	1,370	1,360	1,340	1,330	1,310	1,280	1,260	1,200	1,140
		90	1,120	1,100	1,100	1,090	1,080	1,070	1,060	1,030	1,010
	C	30	1,960	1,950	1,940	1,930	1,920	1,880	1,850	1,760	1,670
		60	1,710	1,700	1,690	1,680	1,670	1,640	1,610	1,540	1,470
		90	1,460	1,450	1,440	1,430	1,420	1,400	1,380	1,330	1,270
⅜	A and B	30	2,220	2,210	2,200	2,180	2,160	2,130	2,080	1,980	1,870
		60	1,870	1,860	1,850	1,840	1,830	1,810	1,770	1,710	1,650
		90	1,530	1,530	1,520	1,520	1,510	1,500	1,480	1,470	1,450
	C	30	2,680	2,670	2,660	2,650	2,640	2,600	2,580	2,490	2,380
		60	2,340	2,330	2,320	2,310	2,300	2,280	2,260	2,180	2,100
		90	1,990	1,980	1,970	1,960	1,950	1,940	1,930	1,890	1,850
7/16	A and B	30	3,230	3,220	3,200	3,190	3,180	3,140	3,100	3,000	2,880
		60	2,730	2,720	2,710	2,700	2,680	2,660	2,640	2,600	2,530
		90	2,230	2,230	2,220	2,220	2,220	2,220	2,220	2,230	2,230
	C	30	3,890	3,880	3,870	3,860	3,850	3,820	3,780	3,710	3,620
		60	3,390	3,380	3,370	3,360	3,360	3,340	3,320	3,260	3,220
		90	2,890	2,880	2,880	2,880	2,870	2,860	2,830	2,840	2,820
½	A and B	30	3,880	3,860	3,850	3,840	3,820	3,770	3,720	3,620	3,500
		60	3,270	3,260	3,260	3,250	3,240	3,220	3,180	3,120	3,060
		90	2,680	2,680	2,680	2,680	2,680	2,680	2,680	2,690	2,700
	C	30	4,660	4,660	4,650	4,640	4,630	4,600	4,550	4,450	4,360
		60	4,050	4,050	4,050	4,040	4,030	4,000	3,970	3,920	3,870
		90	3,460	3,460	3,460	3,460	3,460	3,450	3,440	3,420	3,390
9/16	A and B	30	5,160	5,150	5,140	5,120	5,100	5,070	5,040	4,920	4,800
		60	4,370	4,360	4,350	4,340	4,330	4,300	4,290	4,250	4,210
		90	3,580	3,580	3,580	3,580	3,590	3,600	3,620	3,670	3,710
	C	30	6,210	6,200	6,190	6,180	6,170	6,150	6,110	6,030	5,940
		60	5,410	5,400	5,390	5,380	5,370	5,360	5,350	5,320	5,260
		90	4,610	4,610	4,600	4,600	4,600	4,610	4,620	4,630	4,640
⅝	A and B	30	6,330	6,310	6,300	6,290	6,280	6,240	6,200	6,080	5,980
		60	5,360	5,350	5,340	5,320	5,310	5,300	5,270	5,250	5,230
		90	4,390	4,390	4,390	4,400	4,400	4,420	4,450	4,520	4,590
	C	30	7,620	7,610	7,600	7,590	7,580	7,560	7,510	7,410	7,330
		60	6,620	6,610	6,610	6,610	6,610	6,600	6,590	6,550	6,500
		90	5,650	5,640	5,640	5,640	5,650	5,680	5,690	5,700	5,720

Table 66.—Stringing Tensions for Siemens-Martin Steel Cable

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the sags being such that when loaded at 0° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°*F.*								
5/16	A and B	30	1,210	930	720	520	450	420	410	410
		60	990	770	620	480	440	410	400	400
		90	780	620	530	450	430	400	390	390
	C	30	1,790	1,520	1,270	870	650	570	530	480
		60	1,530	1,290	1,080	760	610	550	520	470
		90	1,300	1,070	980	680	570	520	500	460
3/8	A and B	30	1,940	1,700	1,450	1,070	870	770	730	680
		60	1,620	1,420	1,210	950	820	740	720	670
		90	1,310	1,150	1,020	860	770	710	700	660
	C	30	2,690	2,480	2,250	1,750	1,360	1,110	1,010	870
		60	2,360	2,140	1,920	1,520	1,230	1,040	960	850
		90	2,030	1,830	1,630	1,310	1,100	970	910	830
7/16	A and B	30	3,140	2,910	2,660	2,220	1,840	1,600	1,470	1,340
		60	2,650	2,440	2,250	1,910	1,660	1,490	1,420	1,300
		90	2,190	2,050	1,890	1,650	1,500	1,400	1,350	1,270
	C	30	4,090	3,920	3,740	3,260	2,790	2,400	2,120	1,730
		60	3,600	3,440	3,270	2,860	2,460	2,160	1,980	1,670
		90	3,110	2,960	2,810	2,470	2,160	1,950	1,830	1,610
1/2	A and B	30	3,910	3,660	3,390	2,930	2,540	2,240	2,040	1,790
		60	3,340	3,120	2,900	2,550	2,250	2,040	1,910	1,740
		90	2,780	2,580	2,410	2,180	2,020	1,900	1,810	1,690
	C	30	4,950	4,800	4,600	4,150	3,660	3,260	2,890	2,370
		60	4,360	4,220	4,040	3,650	3,250	2,930	2,660	2,280
		90	3,770	3,650	3,500	3,160	2,840	2,620	2,440	2,180
9/16	A and B	30	5,320	5,120	4,920	4,470	4,040	3,630	3,320	2,920
		60	4,550	4,360	4,180	3,840	3,550	3,270	3,070	2,810
		90	3,780	3,650	3,520	3,330	3,150	2,980	2,860	2,700
	C	30	6,750	6,600	6,410	6,010	5,590	5,100	4,670	3,880
		60	5,940	5,830	5,680	5,340	4,950	4,570	4,260	3,650
		90	5,130	5,050	4,960	4,680	4,320	4,070	3,850	3,470
5/8	A and B	30	6,630	6,460	6,230	5,770	5,340	4,940	4,570	4,030
		60	5,700	5,550	5,360	5,030	4,700	4,420	4,180	3,840
		90	4,770	4,630	4,500	4,300	4,140	4,000	3,870	3,660
	C	30	8,340	8,190	8,030	7,660	7,250	6,800	6,320	5,330
		60	7,370	7,250	7,110	6,790	6,450	6,080	5,670	5,000
		90	6,410	6,310	6,200	5,950	5,670	5,420	5,150	4,670

Table 66.—Stringing Tensions for Siemens-Martin Steel Cable—Con.

MEDIUM LOADING DISTRICT

[At 30, 60, and 90° F., without load, the tensions being such that when loaded at 15° F., the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° F.								
5/16	A and B	30	1,730	1,610	1,500	1,260	1,030	900	820	710
		60	1,480	1,380	1,290	1,090	920	830	770	690
		90	1,240	1,150	1,080	950	830	770	730	680
	C	30	2,190	2,120	2,020	1,830	1,590	1,350	1,190	940
		60	1,940	1,880	1,800	1,610	1,400	1,220	1,090	900
		90	1,690	1,630	1,560	1,400	1,230	1,100	1,020	870
3/8	A and B	30	2,460	2,370	2,260	2,020	1,770	1,560	1,440	1,220
		60	2,120	2,040	1,930	1,760	1,570	1,410	1,330	1,180
		90	1,780	1,710	1,630	1,500	1,390	1,290	1,230	1,140
	C	30	3,070	3,010	2,940	2,750	2,520	2,280	2,060	1,660
		60	2,720	2,670	2,590	2,440	2,240	2,030	1,870	1,560
		90	2,380	2,330	2,260	2,130	1,960	1,800	1,680	1,490
7/16	A and B	30	3,670	3,600	3,490	3,290	3,070	2,860	2,660	2,280
		60	3,180	3,120	3,040	2,880	2,720	2,540	2,410	2,160
		90	2,700	2,650	2,590	2,470	2,370	2,290	2,210	2,060
	C	30	4,530	4,480	4,410	4,240	4,050	3,830	3,600	3,060
		60	4,030	3,990	3,940	3,790	3,620	3,440	3,260	2,860
		90	3,540	3,500	3,460	3,340	3,200	3,050	2,920	2,660
½	A and B	30	4,380	4,330	4,260	4,050	3,810	3,580	3,390	2,940
		60	3,800	3,760	3,700	3,540	3,360	3,200	3,070	2,770
		90	3,230	3,200	3,150	3,040	2,940	2,860	2,800	2,630
	C	30	5,440	5,400	5,340	5,180	4,990	4,760	4,530	3,910
		60	4,840	4,800	4,750	4,620	4,450	4,270	4,090	3,640
		90	4,250	4,200	4,160	4,060	3,950	3,820	3,680	3,390
9/16	A and B	30	5,960	5,880	5,800	5,610	5,380	5,150	4,940	4,460
		60	5,180	5,130	5,060	4,920	4,760	4,590	4,470	4,170
		90	4,400	4,360	4,320	4,230	4,150	4,090	4,030	3,920
	C	30	7,300	7,240	7,180	7,030	6,860	6,650	6,410	5,900
		60	6,470	6,430	6,390	6,280	6,140	5,980	5,800	5,440
		90	5,650	5,630	5,610	5,540	5,450	5,340	5,220	5,030
⅝	A and B	30	7,340	7,260	7,160	6,990	6,800	6,580	6,340	5,750
		60	6,380	6,330	6,270	6,160	6,030	5,880	5,710	5,370
		90	5,420	5,400	5,380	5,330	5,260	5,220	5,160	5,030
	C	30	8,990	8,930	8,860	8,710	8,520	8,320	8,120	7,450
		60	8,010	7,960	7,900	7,790	7,660	7,520	7,370	6,880
		90	7,030	6,990	6,950	6,880	6,800	6,720	6,630	6,360

Table 66.—Stringing Tensions for Siemens-Martin Steel Cable—Con.

LIGHT LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 30° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		°F.								
5/16	A and B	30	2,000	1,970	1,940	1,860	1,780	1,690	1,610	1,410
		60	1,750	1,720	1,700	1,640	1,570	1,510	1,460	1,320
		90	1,510	1,480	1,460	1,420	1,370	1,340	1,310	1,230
	C	30	2,420	2,400	2,380	2,330	2,270	2,190	2,100	1,870
		60	2,170	2,150	2,140	2,090	2,040	1,980	1,910	1,730
		90	1,920	1,910	1,890	1,850	1,820	1,770	1,710	1,590
3/8	A and B	30	2,760	2,750	2,710	2,620	2,510	2,430	2,350	2,090
		60	2,420	2,410	2,380	2,320	2,240	2,180	2,130	1,960
		90	2,080	2,070	2,060	2,020	1,960	1,930	1,910	1,820
	C	30	3,350	3,330	3,300	3,240	3,160	3,080	2,990	2,710
		60	3,010	2,990	2,960	2,910	2,850	2,790	2,710	2,510
		90	2,670	2,650	2,620	2,580	2,540	2,490	2,440	2,310
7/16	A and B	30	4,030	4,000	3,970	3,900	3,810	3,710	3,620	3,370
		60	3,540	3,520	3,500	3,450	3,390	3,330	3,270	3,110
		90	3,050	3,040	3,030	3,000	2,980	2,950	2,930	2,900
	C	30	4,850	4,840	4,820	4,770	4,700	4,620	4,540	4,250
		60	4,340	4,330	4,320	4,290	4,240	4,180	4,130	3,940
		90	3,840	3,830	3,820	3,800	3,780	3,750	3,730	3,630
1/2	A and B	30	4,840	4,810	4,770	4,680	4,560	4,450	4,330	4,090
		60	4,250	4,230	4,200	4,140	4,070	4,000	3,930	3,800
		90	3,670	3,660	3,640	3,610	3,580	3,560	3,560	3,510
	C	30	5,830	5,810	5,780	5,720	5,640	5,550	5,480	5,350
		60	5,220	5,210	5,190	5,150	5,090	5,030	4,960	4,850
		90	4,620	4,610	4,600	4,580	4,550	4,510	4,450	4,360
9/16	A and B	30	6,440	6,420	6,390	6,300	6,180	6,080	6,000	5,880
		60	5,660	5,650	5,640	5,600	5,540	5,470	5,430	5,380
		90	4,870	4,870	4,870	4,870	4,870	4,870	4,870	4,870
	C	30	7,760	7,740	7,700	7,650	7,580	7,500	7,400	7,110
		60	6,930	6,920	6,900	6,860	6,820	6,780	6,730	6,550
		90	6,100	6,100	6,090	6,080	6,070	6,070	6,050	5,980
5/8	A and B	30	7,900	7,880	7,850	7,780	7,680	7,570	7,470	7,140
		60	6,940	6,930	6,920	6,890	6,840	6,800	6,750	6,620
		90	5,990	5,990	5,990	6,000	6,010	6,030	6,050	6,100
	C	30	9,510	9,490	9,460	9,410	9,350	9,250	9,160	8,890
		60	8,500	8,480	8,460	8,430	8,400	8,370	8,330	8,190
		90	7,490	7,480	7,460	7,460	7,480	7,480	7,480	7,490

Table 67.—Stringing Tensions for High-Tension Steel Cable

HEAVY LOADING DISTRICT

[At 30, 60, and 90° F. without load, the tensions being such that when loaded at 0° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of— 200	250	300	400	500	600	700	1,000
		°F.								
5/16	A and B	30	2,990	2,840	2,660	2,250	1,850	1,420	1,130	800
		60	2,700	2,570	2,420	2,040	1,650	1,270	1,040	770
		90	2,420	2,310	2,180	1,830	1,450	1,140	960	740
	C	30	3,670	3,590	3,500	3,240	2,860	2,430	2,060	1,230
		60	3,410	3,340	3,240	2,990	2,640	2,220	1,860	1,160
		90	3,160	3,080	2,990	2,750	2,420	2,000	1,670	1,090
3/8	A and B	30	4,160	4,050	3,920	3,590	3,210	2,760	2,340	1,560
		60	3,810	3,690	3,560	3,260	2,890	2,480	2,110	1,490
		90	3,460	3,340	3,210	2,920	2,580	2,220	1,900	1,420
	C	30	5,150	5,060	4,970	4,740	4,460	4,110	3,640	2,630
		60	4,800	4,710	4,620	4,400	4,120	3,790	3,330	2,500
		90	4,440	4,350	4,270	4,050	3,780	3,460	3,030	2,360
7/16	A and B	30	6,130	6,020	5,910	5,640	5,320	4,960	4,550	3,400
		60	5,630	5,530	5,420	5,170	4,870	4,510	4,140	3,140
		90	5,120	5,030	4,940	4,680	4,390	4,060	3,730	2,930
	C	30	7,500	7,450	7,380	7,200	6,950	6,670	6,350	5,260
		60	7,000	6,950	6,880	6,700	6,470	6,210	5,890	4,850
		90	6,490	6,450	6,380	6,200	5,980	5,710	5,430	4,440
1/2	A and B	30	7,380	7,300	7,200	6,920	6,600	6,230	5,860	4,620
		60	6,770	6,700	6,600	6,350	6,040	5,700	5,350	4,270
		90	6,160	6,100	6,000	5,750	5,460	5,150	4,850	3,940
	C	30	9,050	8,990	8,920	8,750	8,490	8,210	7,910	6,840
		60	8,440	8,380	8,320	8,150	7,900	7,630	7,330	6,340
		90	7,840	7,780	7,710	7,550	7,310	7,050	6,750	5,850
9/16	A and B	30	9,900	9,830	9,750	9,510	9,200	8,850	8,500	7,310
		60	9,100	9,030	8,940	8,710	8,440	8,120	7,790	6,750
		90	8,300	8,240	8,150	7,930	7,670	7,370	7,080	6,210
	C	30	12,080	12,020	11,960	11,800	11,600	11,310	11,020	10,110
		60	11,280	11,210	11,150	10,990	10,800	10,520	10,250	9,420
		90	10,440	10,390	10,330	10,180	10,000	9,750	9,500	8,710
5/8	A and B	30	12,150	12,070	11,980	11,780	11,520	11,150	10,780	9,700
		60	11,160	11,090	11,010	10,820	10,580	10,240	9,890	8,950
		90	10,200	10,140	10,060	9,880	9,640	9,350	9,060	8,240
	C	30	14,800	14,750	14,700	14,570	14,380	14,100	13,820	13,000
		60	13,820	13,780	13,720	13,580	13,380	13,140	12,890	12,100
		90	12,850	12,800	12,730	12,600	12,420	12,180	11,940	11,280

Table 67.—Stringing Tensions for High-Tension Steel Cable—Contd.

MEDIUM LOADING DISTRICT

[At 30, 60, and 90°F. without load, the tensions being such that when loaded at 15°F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of — 200	250	300	400	500	600	700	1,000
		°F.								
5/16	A and B	30	3,200	3,170	3,120	3,000	2,850	2,680	2,490	1,860
		60	2,960	2,920	2,870	2,760	2,610	2,450	2,280	1,720
		90	2,720	2,670	2,630	2,520	2,370	2,220	2,060	1,590
	C	30	3,920	3,890	3,850	3,770	3,650	3,520	3,370	2,870
		60	3,670	3,630	3,590	3,510	3,400	3,270	3,130	2,650
		90	3,410	3,380	3,340	3,250	3,150	3,030	2,900	2,440
3/8	A and B	30	4,450	4,420	4,370	4,260	4,140	3,980	3,790	3,120
		60	4,100	4,060	4,030	3,930	3,810	3,660	3,490	2,920
		90	3,760	3,730	3,690	3,600	3,480	3,340	3,180	2,720
	C	30	5,400	5,380	5,350	5,270	5,190	5,060	4,900	4,230
		60	5,050	5,030	5,000	4,930	4,850	4,720	4,560	3,920
		90	4,690	4,680	4,660	4,580	4,500	4,380	4,220	3,640
7/16	A and B	30	6,470	6,440	6,400	6,310	6,200	6,060	5,870	5,340
		60	5,980	5,940	5,900	5,820	5,710	5,590	5,430	4,940
		90	5,490	5,450	5,420	5,330	5,230	5,120	4,940	4,540
	C	30	7,840	7,820	7,800	7,740	7,650	7,550	7,450	7,000
		60	7,320	7,310	7,290	7,240	7,150	7,060	6,960	6,560
		90	6,810	6,800	6,780	6,730	6,650	6,570	6,470	6,120
1/2	A and B	30	7,770	7,740	7,700	7,610	7,500	7,330	7,170	6,690
		60	7,180	7,150	7,120	7,030	6,900	6,760	6,620	6,190
		90	6,580	6,540	6,500	6,430	6,320	6,190	6,070	5,700
	C	30	9,410	9,390	9,360	9,290	9,200	9,090	8,960	8,550
		60	8,800	8,780	8,750	8,690	8,610	8,520	8,380	8,000
		90	8,190	8,180	8,150	8,100	8,010	7,920	7,810	7,460
9/16	A and B	30	10,370	10,340	10,310	10,230	10,120	9,980	9,820	9,370
		60	9,590	9,550	9,520	9,450	9,350	9,220	9,080	8,690
		90	8,780	8,740	8,710	8,650	8,550	8,460	8,350	8,030
	C	30	12,530	12,510	12,500	12,440	12,370	12,270	12,140	11,780
		60	11,700	11,680	11,660	11,620	11,570	11,490	11,360	11,000
		90	10,910	10,880	10,860	10,810	10,770	10,700	10,580	10,260
5/8	A and B	30	12,700	12,680	12,650	12,560	12,440	12,320	12,190	11,720
		60	11,710	11,700	11,690	11,600	11,500	11,390	11,260	10,890
		90	10,740	10,720	10,700	10,640	10,540	10,440	10,330	10,060
	C	30	15,380	15,350	15,320	15,250	15,200	15,100	15,000	14,550
		60	14,380	14,350	14,330	14,280	14,200	14,130	14,040	13,660
		90	13,380	13,370	13,350	13,320	13,250	13,170	13,100	12,780

Table 67.—Stringing Tensions for High-Tension Steel Cable—Contd.

LIGHT LOADING DISTRICT

[At 30, 60, and 90° without load the tensions being such that when loaded at 30° F. the cable will be stressed to 50 per cent of ultimate strength for grades A and B, and to 60 per cent for grade C]

Cable diameter (inches)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	700	1,000
		° F.								
5/16	A and B	30	3,390	3,380	3,370	3,340	3,300	3,260	3,200	3,030
		60	3,140	3,130	3,120	3,090	3,050	3,020	2,960	2,810
		90	2,880	2,870	2,860	2,840	2,810	2,780	2,740	2,590
	C	30	4,080	4,070	4,060	4,040	4,020	3,980	3,950	3,800
		60	3,820	3,810	3,800	3,790	3,760	3,730	3,700	3,560
		90	3,560	3,560	3,550	3,540	3,510	3,480	3,450	3,330
3/8	A and B	30	4,660	4,650	4,650	4,620	4,580	4,540	4,470	4,280
		60	4,310	4,310	4,300	4,280	4,240	4,210	4,150	3,990
		90	3,970	3,960	3,960	3,940	3,910	3,880	3,840	3,710
	C	30	5,610	5,600	5,600	5,570	5,550	5,510	5,470	5,320
		60	5,250	5,250	5,240	5,220	5,200	5,170	5,140	4,990
		90	4,900	4,900	4,890	4,880	4,860	4,840	4,820	4,670
7/16	A and B	30	6,770	6,760	6,730	6,710	6,670	6,610	6,550	6,380
		60	6,260	6,250	6,230	6,220	6,180	6,130	6,100	5,960
		90	5,760	5,750	5,740	5,730	5,700	5,660	5,630	5,540
	C	30	8,130	8,120	8,100	8,080	8,050	8,020	7,980	7,840
		60	7,620	7,600	7,590	7,580	7,560	7,530	7,490	7,360
		90	7,100	7,090	7,080	7,080	7,060	7,040	7,000	6,870
1/2	A and B	30	8,110	8,100	8,090	8,060	8,010	7,960	7,900	7,650
		60	7,510	7,500	7,490	7,470	7,430	7,380	7,330	7,160
		90	6,910	6,900	6,890	6,870	6,840	6,810	6,770	6,650
	C	30	9,740	9,730	9,720	9,690	9,670	9,650	9,590	9,420
		60	9,130	9,120	9,110	9,090	9,080	9,060	9,000	8,850
		90	8,510	8,500	8,490	8,480	8,470	8,460	8,410	8,280
9/16	A and B	30	10,790	10,780	10,770	10,750	10,710	10,650	10,600	10,300
		60	10,010	9,990	9,980	9,950	9,920	9,860	9,800	9,630
		90	9,190	9,180	9,170	9,150	9,140	9,100	9,050	8,940
	C	30	12,970	12,960	12,940	12,930	12,900	12,880	12,850	12,670
		60	12,150	12,140	12,130	12,110	12,090	12,080	12,060	11,900
		90	11,320	11,320	11,310	11,300	11,300	11,290	11,280	11,160
5/8	A and B	30	13,230	13,220	13,210	13,200	13,150	13,100	13,020	12,800
		60	12,280	12,280	12,280	12,250	12,210	12,180	12,120	11,960
		90	11,280	11,280	11,280	11,260	11,240	11,220	11,200	11,130
	C	30	15,890	15,880	15,870	15,840	15,830	15,800	15,770	15,600
		60	14,890	14,880	14,870	14,850	14,830	14,810	14,780	14,670
		90	13,890	13,880	13,880	13,860	13,850	13,840	13,820	13,730

Table 68.—Stringing Tensions for Bare Copper-Covered Steel Wire (Ordinary Grade)

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the wires will be stressed to 50 per cent of their ultimate strength]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—						
			100	125	150	175	200	250	300
		° F.							
6	A and B	30	637	530	424	310			
		60	548	441	341	246			
		90	460	352	264	197			
4	A and B	30	1,037	964	863	752	635	400	274
		60	901	822	729	620	507	314	244
		90	764	685	594	495	400	275	222

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the wires will be stressed to 50 per cent of their ultimate strength]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			100	125	150	175	200	250	300	400
		° F.								
8	B	30	511	479	437					
		60	455	423	384					
		90	400	368	327					
6	A and B	30	807	780	747	706				
		60	719	691	660	619				
		90	629	602	570	532				
4	A and B	30	1,210	1,190	1,160	1,130	1,087	998	894	670
		60	1,070	1,050	1,020	988	949	860	767	572
		90	933	910	881	850	826	734	648	484

Table 68.—Stringing Tensions for Bare Copper-Covered Steel Wire (Ordinary Grade)—Continued

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F. the wires will be stressed to 50 per cent of their ultimate strength]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—					
			100	150	200	300	400	500
		° F.						
8	B	30	595	590				
		60	540	534				
		90	484	478				
6	A and B	30	893	886	877			
		60	805	799	790			
		90	718	711	702			
4	A and B	30	1,323	1,302	1,300	1,287	1,225	1,176
		60	1,180	1,162	1,160	1,152	1,093	1,052
		90	1,038	1,024	1,022	996	967	931

Table 69.—Stringing Tensions for Bare Copper-Covered Steel Cable

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the cable will be stressed to 50 per cent of its ultimate strength]

Size (inch)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			200	250	300	400	500	600	800	1,000
		° F.								
5/16	A and B	30	2,260	2,105	1,885	1,455	1,065			
		60	2,020	1,870	1,660	1,260	940			
		90	1,790	1,605	1,440	1,105	840			
3/8	A and B	30	3,600	3,435	3,285	2,920	2,505	2,100	1,586	
		60	3,240	3,080	2,940	2,600	2,220	1,887	1,490	
		90	2,885	2,740	2,595	2,290	1,970	1,700	1,405	
7/16	A and B	30	4,309	4,280	4,110	3,760	3,350	2,930	2,320	1,995
		60	3,960	3,850	3,700	3,360	2,990	2,640	2,160	1,910
		90	3,530	3,425	3,285	2,985	2,665	2,380	2,010	1,835
1/2	A and B	30	5,585	5,480	5,330	5,015	4,625	4,230	3,485	2,985
		60	5,060	4,960	4,820	4,520	4,180	3,830	3,210	2,830
		90	4,560	4,465	4,325	4,055	3,745	3,460	2,960	2,685
9/16	A and B	30	6,845	6,790	6,660	6,380	6,020	5,635	4,875	4,260
		60	6,280	6,180	6,050	5,800	5,470	5,130	4,480	4,010
		90	5,650	5,570	5,460	5,220	4,940	4,660	4,140	3,810

Table 69.—Stringing Tensions for Bare Copper-Covered Steel Cable—Continued

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the cable will be stressed to 50 per cent of its ultimate strength]

Size (inch)	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of— 100	250	400	600	800	1,000
		°F.						
5/16	A and B	30	2,660	2,540	2,330	1,940	--------	--------
		60	2,420	2,300	2,100	1,750	--------	--------
		90	2,180	2,070	1,880	1,570	--------	--------
3/8	A and B	30	4,000	3,890	3,710	3,330	2,940	--------
		60	3,630	3,540	3,370	3,040	2,710	--------
		90	3,270	3,180	3,020	2,730	2,470	--------
7/16	A and B	30	4,830	4,750	4,560	4,230	3,850	3,490
		60	4,400	4,320	4,150	3,850	3,530	3,250
		90	3,960	3,890	3,760	3,490	3,240	3,030
1/2	A and B	30	6,030	5,930	5,760	5,450	5,080	4,710
		60	5,500	5,410	5,260	4,990	4,690	4,390
		90	4,970	4,900	4,770	4,530	4,320	4,090
9/16	A and B	30	7,370	7,280	7,150	6,820	6,470	6,110
		60	6,740	6,660	6,520	6,270	5,980	5,690
		90	6,120	6,050	5,930	5,740	5,520	5,310

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F. the cable will be stressed to 50 per cent of its ultimate strength]

5/16	A and B	30	2,800	2,760	2,710	2,610	2,460	--------
		60	2,560	2,530	2,480	2,390	2,260	--------
		90	2,320	2,290	2,220	2,180	2,070	--------
3/8	A and B	30	4,190	4,170	4,105	4,000	3,900	3,720
		60	3,830	3,810	3,755	3,670	3,570	3,490
		90	3,470	3,440	3,400	3,350	3,270	3,190
7/16	A and B	30	5,030	5,020	4,970	4,880	4,740	4,590
		60	4,640	4,610	4,570	4,480	4,380	4,270
		90	4,200	4,180	4,150	4,090	4,020	3,960
1/2	A and B	30	6,300	6,270	6,200	6,100	5,960	5,810
		60	5,780	5,750	5,700	5,620	5,520	5,420
		90	5,260	5,230	5,210	5,160	5,100	5,040
9/16	A and B	30	7,700	7,660	7,660	7,490	7,360	7,210
		60	7,070	7,040	7,000	6,920	6,830	6,730
		90	6,450	6,430	6,410	6,370	6,320	6,280

Table 70.—Stringing Tensions for Bare Stranded Aluminum

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the conductor will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			100	125	150	200	250	300	400	600
		°F.								
1	A and B	30	96	73	66	------	------	------	------	------
		60	66	59	53	------	------	------	------	------
		90	53	50	50	------	------	------	------	------
	C	30	267	149	99	------	------	------	------	------
		60	125	89	79	------	------	------	------	------
		90	73	69	66	------	------	------	------	------
0	A and B	30	199	125	108	95	87	87	83	------
		60	108	91	91	87	83	83	79	------
		90	79	75	75	75	75	75	75	------
	C	30	527	315	216	133	112	108	104	------
		60	273	162	133	112	104	104	100	------
		90	116	104	104	100	100	95	91	------
00	A and B	30	378	263	200	152	147	137	131	------
		60	173	152	142	131	131	131	126	------
		90	121	116	116	121	121	126	126	------
	C	30	709	593	420	252	194	179	168	152
		60	378	305	231	189	173	163	158	147
		90	173	168	158	158	152	152	147	147
000	A and B	30	640	488	370	251	218	211	198	185
		60	304	251	231	205	198	191	191	185
		90	165	165	172	172	178	185	185	185
	C	30	1,030	871	759	455	330	290	264	231
		60	601	482	409	304	264	251	244	224
		90	277	244	251	231	224	224	224	224
0000	A and B	30	938	747	623	398	349	324	291	282
		60	448	415	349	299	291	291	274	266
		90	232	232	241	249	257	266	266	266
	C	30	1,370	1,295	1,104	780	589	452	365	349
		60	772	722	631	465	415	365	349	340
		90	374	374	340	332	332	332	324	324

Table 70.—Stringing Tensions for Bare Stranded Aluminum—Contd.

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the conductor will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	200	250	300	400	500	600
		°F.									
1	A and B	30	426	337	254	------	------	------	------	------	------
		60	224	172	137	------	------	------	------	------	------
		90	102	99	96	------	------	------	------	------	------
	C	30	620	535	472	------	------	------	------	------	------
		60	399	317	277	------	------	------	------	------	------
		90	198	162	152	------	------	------	------	------	------
0	A and B	30	598	523	427	261	199	174	154	145	141
		60	336	274	237	174	162	154	145	141	133
		90	149	145	145	137	137	137	137	137	137
	C	30	822	768	697	552	374	274	208	191	183
		60	531	498	427	315	249	216	187	178	174
		90	282	253	237	203	187	183	174	170	170
00	A and B	30	830	746	672	467	347	284	247	226	221
		60	473	425	373	289	252	236	226	215	210
		90	221	210	210	205	205	205	205	205	205
	C	30	1,087	1,040	982	824	641	494	352	305	278
		60	735	683	646	625	410	347	299	278	263
		90	399	382	352	310	278	273	263	257	252
000	A and B	30	1,089	1,010	937	746	581	455	442	343	323
		60	640	587	548	442	396	350	337	317	310
		90	304	297	297	297	297	297	297	297	297
	C	30	1,412	1,360	1,294	1,142	990	812	568	469	429
		60	964	911	865	746	647	542	455	416	396
		90	528	502	482	442	422	403	383	376	370
0000	A and B	30	1,411	1,328	1,262	1,038	896	706	589	515	490
		60	855	789	747	614	581	523	490	465	457
		90	407	407	407	407	415	415	432	432	432
	C	30	1,785	1,743	1,594	1,552	1,378	1,187	921	739	656
		60	1,220	1,179	1,162	1,038	896	797	689	614	589
		90	681	664	647	614	581	573	564	540	540

Table 70.—Stringing Tensions for Bare Stranded Aluminum—Contd.

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F., the conductor will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—								
			100	125	150	200	250	300	400	500	600
		°F.									
1	A and B	30	660	634	597	------	------	------	------	------	------
		60	436	409	383	------	------	------	------	------	------
		90	228	218	208	------	------	------	------	------	------
	C	30	828	812	776	------	------	------	------	------	------
		60	597	574	551	------	------	------	------	------	------
		90	380	353	340	------	------	------	------	------	------
0	A and B	30	838	813	780	714	606	506	361	303	274
		60	564	535	510	465	423	340	286	270	253
		90	303	291	278	278	257	253	241	232	232
	C	30	1,042	1,021	988	934	855	784	593	452	378
		60	751	739	668	660	598	549	427	361	332
		90	477	465	440	411	390	361	328	307	295
00	A and B	30	1,087	1,055	1,024	935	845	719	536	452	404
		60	730	698	677	614	557	478	415	378	368
		90	399	383	378	373	362	347	336	336	336
	C	30	1,323	1,302	1,292	1,218	1,145	1,045	840	683	572
		60	966	940	914	872	809	730	609	525	483
		90	614	599	578	557	536	494	452	431	425
000	A and B	30	1,366	1,360	1,313	1,214	1,129	1,010	818	640	581
		60	917	904	878	865	746	680	601	535	515
		90	502	502	502	482	482	469	469	455	455
	C	30	1,663	1,650	1,630	1,577	1,511	1,406	1,214	997	858
		60	1,214	1,201	1,175	1,135	1,089	1,003	878	759	700
		90	772	766	752	733	713	680	634	601	594
0000	A and B	30	1,735	1,693	1,668	1,594	1,486	1,370	1,137	930	830
		60	1,170	1,145	1,121	1,071	996	930	822	755	706
		90	639	639	639	639	639	639	631	631	631
	C	30	2,108	2,075	2,067	2,017	1,934	1,834	1,627	1,411	1,204
		60	1,544	1,519	1,511	1,461	1,403	1,320	1,204	1,054	963
		90	988	963	963	955	930	905	863	830	797

Table 71.—Stringing Tensions for Bare Stranded Aluminum, Steel-Reinforced

HEAVY LOADING DISTRICT

[The tensions being such that when loaded at 0° F. the cable will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			100	150	200	300	400	500	700	1,000
		°F.								
4	A and B	30	282	80	57	49	46	45		
		60	155	64	53	47	46	45		
		90	81	55	49	46	45	45		
	C	30	528	258	98	64	58	56		
		60	385	153	81	61	57	55		
		90	246	98	70	59	56	55		
2	A and B	30	732	454	219	132	117	112		
		60	507	274	163	122	113	109		
		90	296	170	133	115	109	107		
	C	30	1,043	840	570	212	158	143	127	
		60	815	618	380	180	149	139	126	
		90	588	407	248	159	141	134	124	
1	A and B	30	1,005	756	462	226	188	182	165	161
		60	720	494	303	199	178	169	163	160
		90	446	293	220	180	169	165	161	159
	C	30	1,365	1,188	946	435	273	233	207	197
		60	1,077	904	678	329	246	221	203	194
		90	792	629	447	267	225	211	199	194
0	A and B	30	1,345	1,127	841	411	307	276	255	245
		60	984	781	554	334	282	264	249	243
		90	633	479	365	284	262	252	245	241
	C	30	1,777	1,610	1,408	865	499	387	326	302
		60	1,414	1,251	1,059	619	418	355	315	297
		90	1,052	898	734	457	364	330	305	294
00	A and B	30	1,768	1,575	1,316	768	521	445	393	372
		60	1,310	1,134	911	567	454	411	384	369
		90	865	722	588	451	405	387	372	366
	C	30	2,290	2,155	1,968	1,466	948	677	523	468
		60	1,832	1,712	1,522	1,079	734	588	496	458
		90	1,376	1,253	1,093	772	596	523	473	449
000	A and B	30	2,275	2,106	1,875	1,299	884	715	607	561
		60	1,698	1,545	1,337	930	722	638	576	553
		90	1,137	1,007	876	692	615	584	553	538
	C	30	2,916	2,793	2,624	2,162	1,616	1,173	834	714
		60	2,335	2,218	2,058	1,642	1,220	960	772	692
		90	1,762	1,652	1,510	1,187	942	814	718	672
0000	A and B	30	2,938	2,782	2,569	2,026	1,493	1,192	950	863
		60	2,210	2,065	1,881	1,464	1,154	1,008	892	834
		90	1,483	1,386	1,270	1,057	940	882	834	805
	C	30	3,740	3,632	3,482	3,068	2,539	2,007	1,379	1,118
		60	3,010	2,909	2,767	2,384	1,950	1,589	1,228	1,068
		90	2,283	2,190	2,069	1,762	1,480	1,287	1,110	1,023

Table 71.—Stringing Tensions for Bare Stranded Aluminum, Steel-Reinforced—Continued

MEDIUM LOADING DISTRICT

[The tensions being such that when loaded at 15° F. the cable will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C]

Size A. W. G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of—							
			100	150	200	300	400	500	700	1,000
		°F.								
4	A and B	30	579	457	301	126	99	91	-------	------
		60	435	320	195	109	93	88	-------	------
		90	294	198	132	97	88	85	-------	------
	C	30	759	673	555	272	150	123	-------	------
		60	614	530	417	197	133	116	-------	------
		90	471	390	288	153	120	110	-------	------
2	A and B	30	1,079	913	786	477	295	240	-------	------
		60	851	688	571	344	251	220	-------	------
		90	624	472	381	261	220	205	-------	------
	C	30	1,268	1,203	1,112	862	573	385	-------	------
		60	1,039	975	887	655	435	327	-------	------
		90	810	749	667	474	342	286	-------	------
1	A and B	30	1,290	1,203	1,088	788	519	396	321	292
		60	999	919	812	569	413	349	305	286
		90	715	643	558	411	343	314	291	280
	C	30	1,617	1,549	1,467	1,240	953	687	453	375
		60	1,328	1,262	1,183	970	728	552	414	362
		90	1,040	977	903	720	554	458	383	351
0	A and B	30	1,646	1,570	1,466	1,187	879	665	504	444
		60	1,283	1,211	1,115	878	670	555	468	430
		90	923	861	783	629	529	480	439	418
	C	30	2,042	1,990	1,916	1,711	1,441	1,149	754	583
		60	1,678	1,626	1,556	1,363	1,127	904	663	555
		90	1,314	1,267	1,202	1,035	857	721	595	530
00	A and B	30	2,099	2,031	1,937	1,680	1,370	1,086	797	674
		60	1,641	1,577	1,491	1,267	1,039	872	718	646
		90	1,187	1,134	1,065	915	795	723	655	620
	C	30	2,593	2,545	2,478	2,292	2,043	1,755	1,232	914
		60	2,133	2,088	2,024	1,850	1,627	1,393	1,042	850
		90	1,675	1,633	1,576	1,426	1,253	1,097	901	797
000	A and B	30	2,657	2,594	2,507	2,270	1,969	1,660	1,237	1,014
		60	2,079	2,021	1,943	1,738	1,508	1,310	1,080	957
		90	1,507	1,462	1,403	1,268	1,142	1,056	962	907
	C	30	3,271	3,227	3,165	2,994	2,763	2,487	1,920	1,413
		60	2,691	2,650	2,591	2,433	2,227	1,998	1,591	1,283
		90	2,113	2,076	2,026	1,893	1,734	1,575	1,340	1,178
0000	A and B	30	3,382	3,324	3,244	3,023	2,740	2,429	1,904	1,537
		60	2,653	2,601	2,530	2,344	2,125	1,915	1,615	1,420
		90	1,929	1,892	1,844	1,728	1,611	1,517	1,401	1,325
	C	30	4,154	4,114	4,057	3,899	3,685	3,426	3,025	2,177
		60	3,424	3,385	3,334	3,190	3,002	2,784	2,501	1,931
		90	2,694	2,662	2,620	2,503	2,361	2,210	2,069	1,737

Table 71.—Stringing Tensions for Bare Stranded Aluminum, Steel-Reinforced—Continued

LIGHT LOADING DISTRICT

[The tensions being such that when loaded at 30° F. the cable will be stressed to 50 per cent of the ultimate strength for grades A and B and 60 per cent for grade C]

Size A.W.G. No.	Grade of construction	Temperature	Tensions (in pounds) for span lengths (in feet) of— 100	150	200	300	400	500	700	1,000
		°F.								
4	A and B	30	729	702	666	565	442	331	-------	------
		60	585	559	525	434	336	260	-------	------
		90	441	418	388	316	256	222	-------	------
	C	30	885	870	842	769	673	560	-------	------
		60	741	723	698	629	540	445	-------	------
		90	597	579	556	493	419	350	-------	------
2	A and B	30	1,176	1,150	1,114	1,012	882	739	-------	------
		60	947	922	888	796	686	581	-------	------
		90	719	697	668	595	521	463	-------	------
	C	30	1,422	1,403	1,377	1,306	1,208	1,090	-------	------
		60	1,192	1,174	1,150	1,082	992	887	-------	------
		90	963	947	924	863	787	705	-------	------
1	A and B	30	1,479	1,452	1,415	1,313	1,179	1,027	766	592
		60	1,190	1,165	1,131	1,039	919	812	648	550
		90	903	882	854	783	707	642	562	514
	C	30	1,785	1,766	1,741	1,668	1,570	1,449	1,174	853
		60	1,496	1,478	1,454	1,386	1,296	1,189	970	758
		90	1,208	1,192	1,170	1,110	1,034	951	804	683
0	A and B	30	1,869	1,842	1,805	1,703	1,568	1,410	1,107	856
		60	1,505	1,480	1,447	1,356	1,242	1,121	923	781
		90	1,142	1,122	1,097	1,028	953	883	786	720
	C	30	2,253	2,235	2,209	2,136	2,037	1,916	1,628	1,241
		60	1,888	1,871	1,847	1,779	1,689	1,582	1,350	1,085
		90	1,524	1,509	1,488	1,430	1,356	1,274	1,116	962
00	A and B	30	2,364	2,337	2,301	2,198	2,061	1,901	1,568	1,232
		60	1,904	1,880	1,848	1,758	1,646	1,521	1,297	1,106
		90	1,448	1,429	1,404	1,341	1,269	1,198	1,091	1,007
	C	30	2,847	2,829	2,803	2,731	2,631	2,509	2,214	1,774
		60	2,387	2,370	2,347	2,280	2,191	2,084	1,844	1,535
		90	1,928	1,913	1,893	1,838	1,768	1,687	1,524	1,345
000	A and B	30	2,977	2,949	2,913	2,810	2,673	2,510	2,152	1,742
		60	2,398	2,375	2,342	2,256	2,144	2,018	1,779	1,542
		90	1,821	1,804	1,783	1,725	1,660	1,591	1,479	1,385
	C	30	3,583	3,564	3,537	3,465	3,366	3,242	2,942	2,461
		60	3,003	2,985	2,962	2,896	2,810	2,705	2,461	2,120
		90	2,424	2,409	2,390	2,339	2,272	2,196	2,035	1,841
0000	A and B	30	3,774	3,747	3,710	3,608	3,471	3,306	2,934	2,453
		60	3,043	3,021	2,990	2,906	2,796	2,674	2,424	2,147
		90	2,316	2,303	2,283	2,234	2,176	2,116	2,012	1,908
	C	30	4,540	4,521	4,495	4,423	4,323	4,200	3,897	3,387
		60	3,807	3,791	3,768	3,705	3,620	3,517	3,275	2,912
		90	3,077	3,065	3,047	3,001	2,939	2,870	2,715	2,517

Appendix C.—SAGS FOR LINE CONDUCTORS STRUNG TO THE 2,000-POUND LIMITATION

By stringing conductors so that, under the worst assumed condition of loading, the tension in the conductor does not exceed 2,000 pounds, the required strength of cross arms and pins is similarly limited. (See rules 261, D, 3, and 261, E, 1.) Values of sag at a stringing temperature of 60° F. which will keep the tension when loaded within this limit are given for conductor sizes having an ultimate strength in excess of 4,000 pounds. Figures 2 to 13 give the sag values for copper, and Figures 14, 15, and 16 for aluminum cable with steel core.

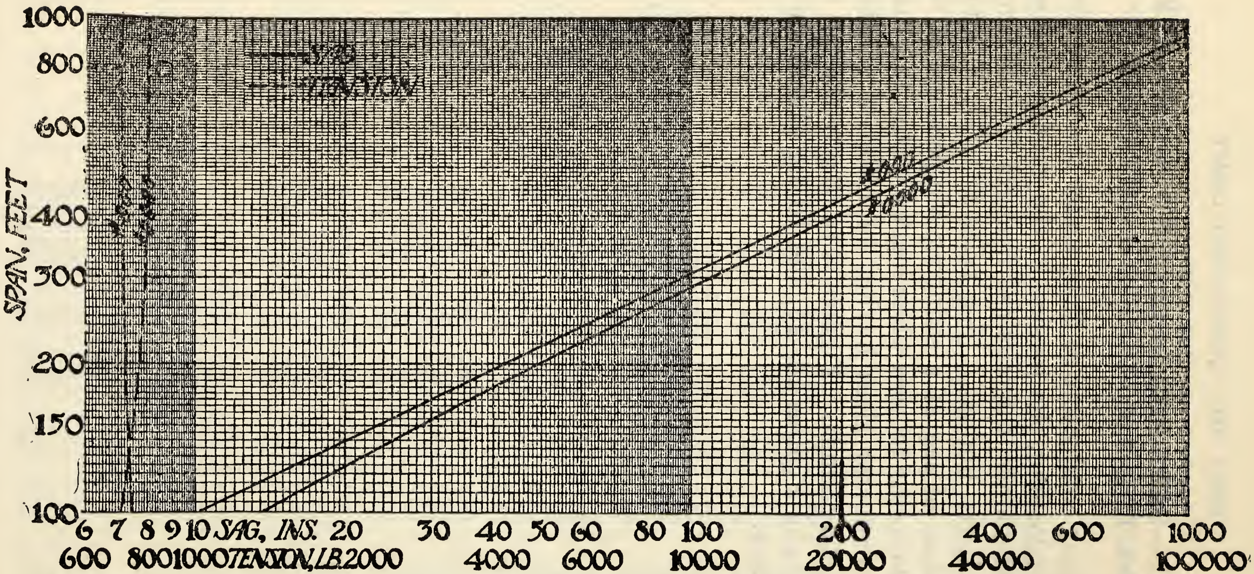

Fig. 2.—*Sags and tensions at 60° F., heavy loading district. Bare, solid, soft or hard-drawn copper wire, Nos. 3/0 and 4/0*

Tension when loaded at 0° F. is 2,000 pounds

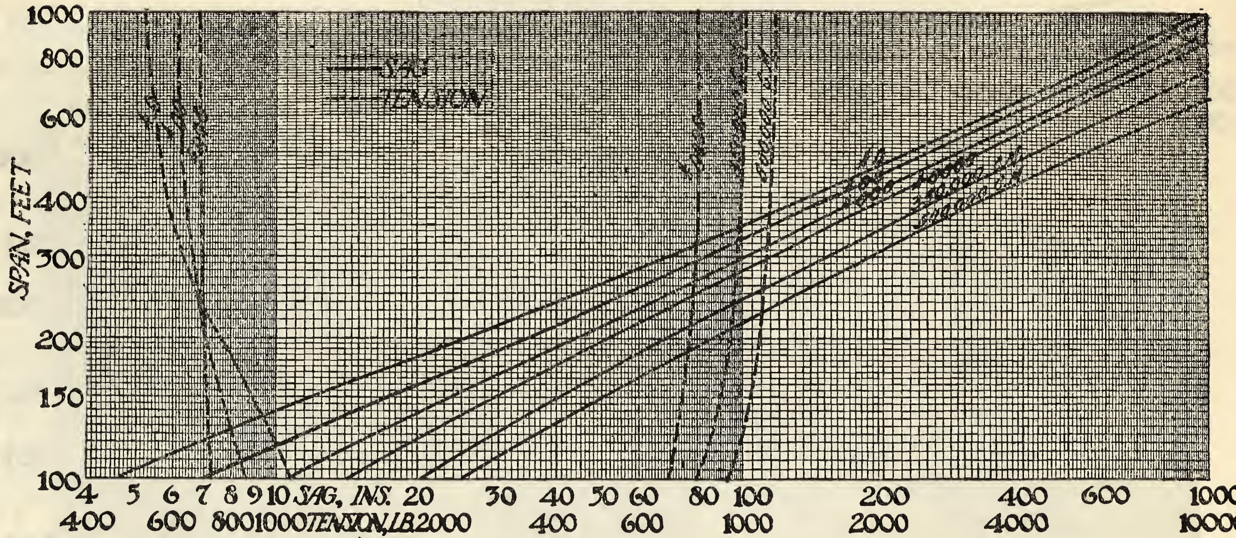

FIG. 3.—*Sags and tensions at 60° F., heavy loading district. Bare, stranded, hard-drawn copper conductors, Nos. 1/0, 2/0, 3/0, and 4/0, 350,000 c. m., and 500,000 c. m.; soft copper Nos. 3/0 and 4/0, 350,000 c. m., and 500,000* **c. m.**

Tension when loaded at 0° F. is 2,000 pounds

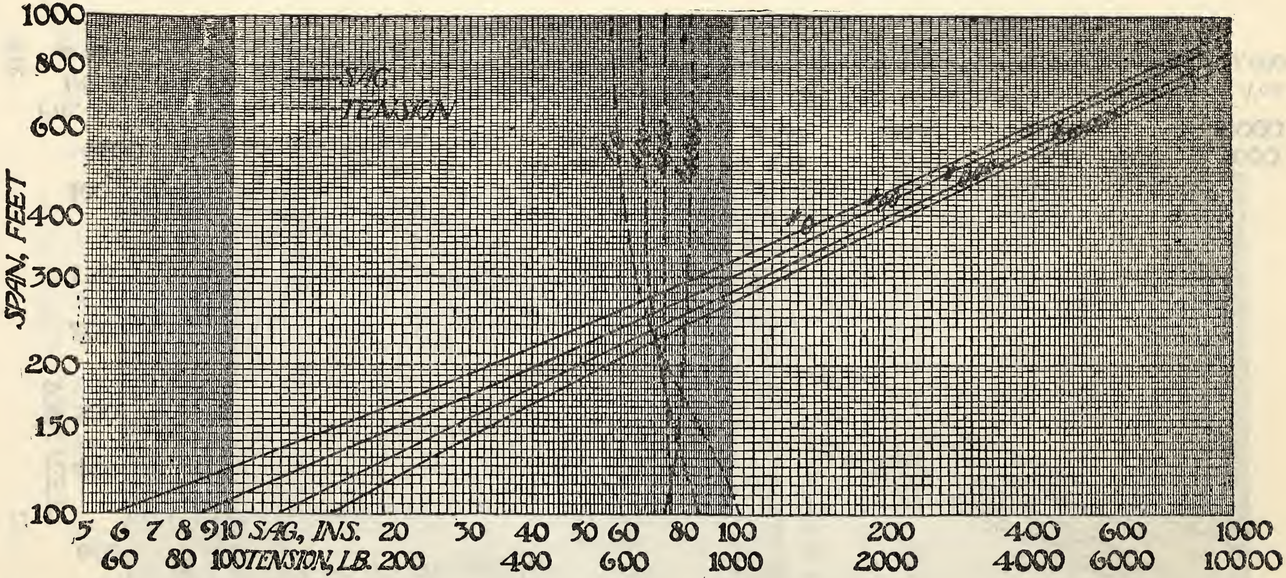

Fig. 4.—*Sags and tensions at 60° F., heavy loading district. Triple-braid weatherproof, solid, hard-drawn copper wire, Nos. 1/0, 2/0, 3/0, and 4/0; soft copper Nos. 3/0 and 4/0*

Tension when loaded at 0° F. is 2,000 pounds

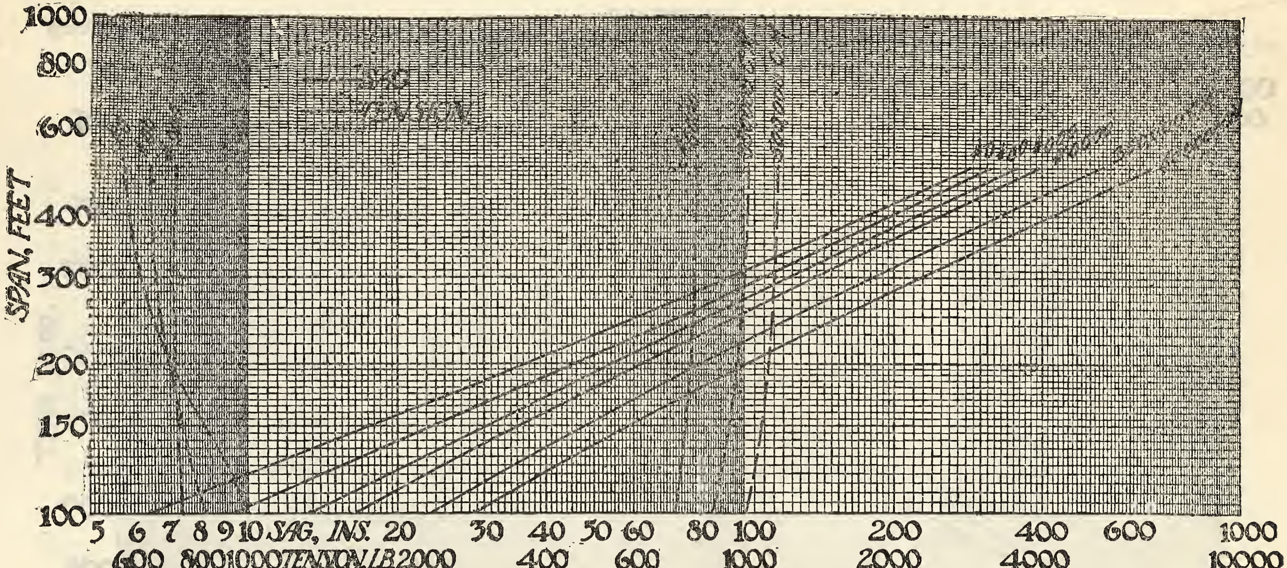

Fig. 5.—*Sags and tensions at 60° F., heavy loading district. Triple-braid weatherproof, stranded, hard-drawn copper conductors, Nos. 1/0, 2/0, 3/0, and 4/0, 350,000 c. m., and 500,000 c. m.; soft copper Nos. 3/0 and 4/0, 350,000 c. m., and 500,000 c. m.*

Tension when loaded at 0° F. is 2,000 pounds

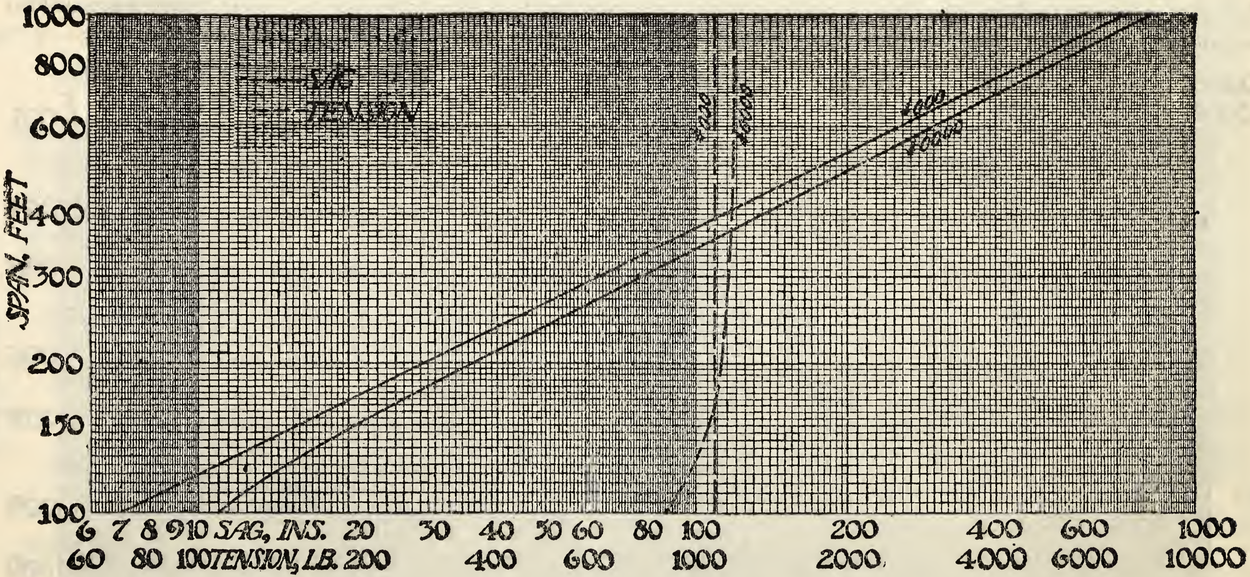

FIG. 6.—*Sags and tensions at 60° F., medium loading district. Bare, solid, soft or hard-drawn copper wire, Nos. 3/0 and 4/0*

Tension when loaded at 15° F. is 2,000 pounds

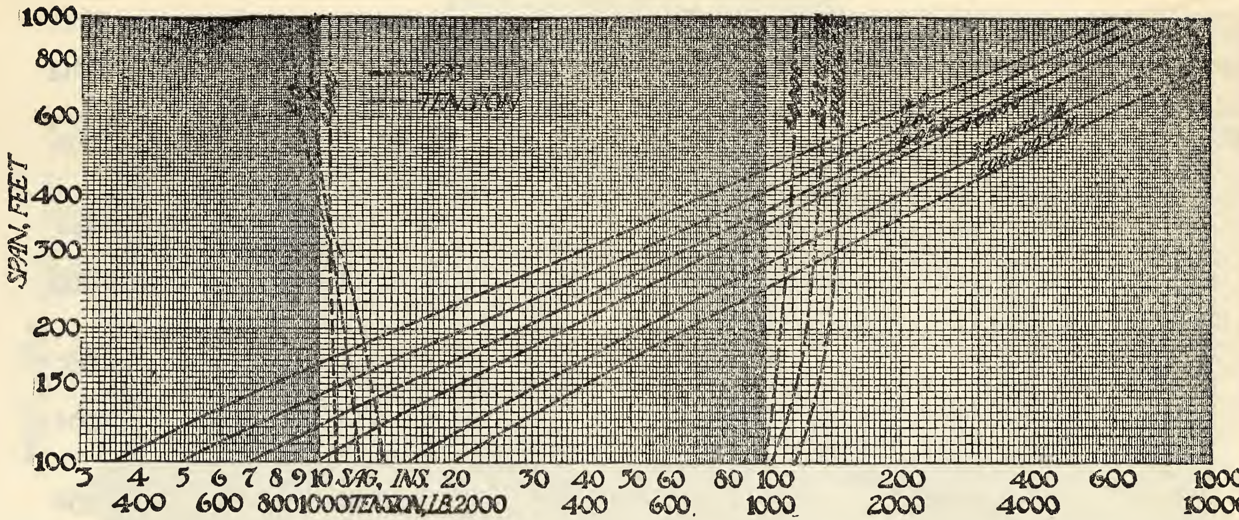

Fig. 7.—*Sags and tensions at 60° F., medium loading district. Bare, stranded, hard-drawn copper conductors, Nos. 1/0, 2/0, 3/0, and 4/0, 350,000 c. m., and 500,000 c. m.; soft copper Nos. 3/0 and 4/0, 350,000 c. m., and 500,000 c. m.*

Tension when loaded at 15° F. is 2,000 pounds

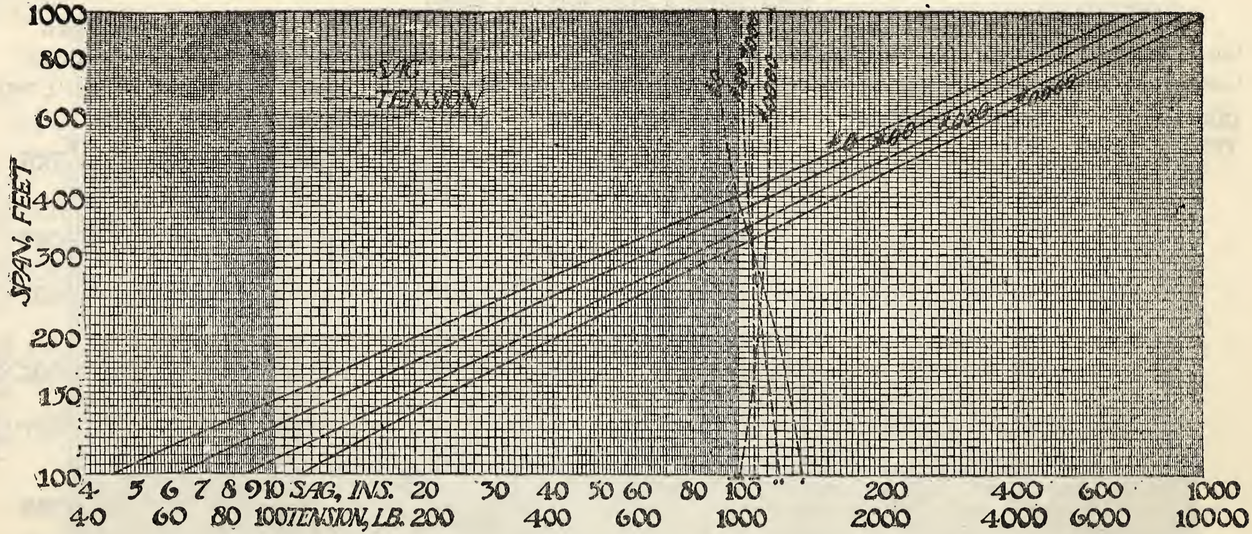

Fig. 8.—*Sags and tensions at 60° F., medium loading district. Triple-braid weatherproof, solid, hard-drawn copper wire, Nos. 1/0, 2/0, 3/0, and 4/0; soft copper Nos. 3/0 and 4/0*

Tension when loaded at 15° F. is 2,000 pounds

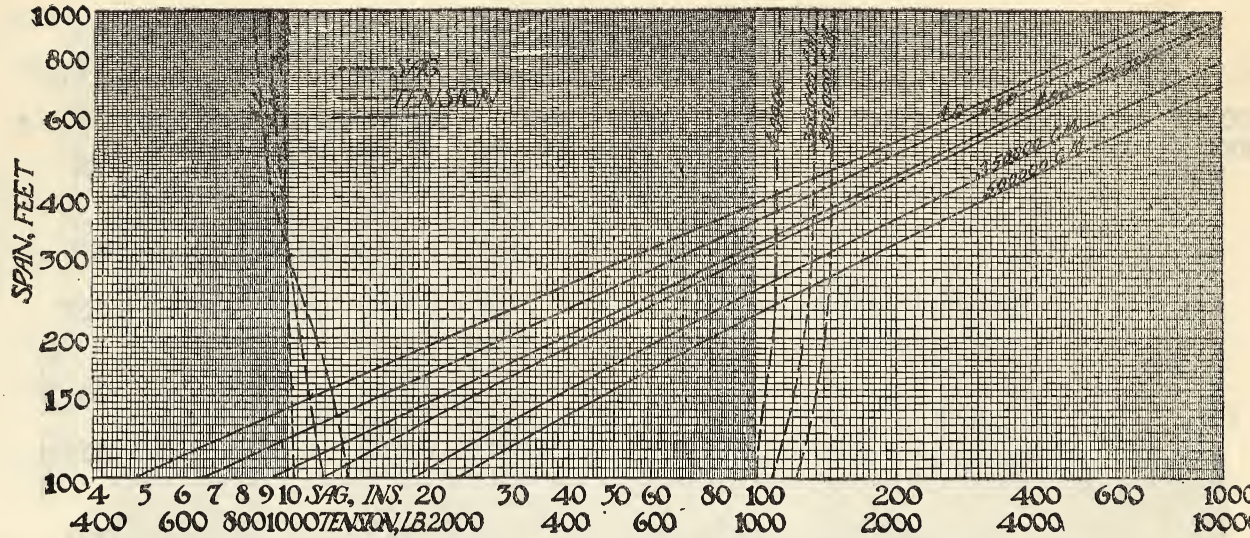

FIG. 9.—*Sags and tensions at 60° F., medium loading district. Triple-braid weatherproof, stranded, hard-drawn copper wire, Nos. 1/0, 2/0, 3/0, and 4/0, 350,000 c. m., and 500,000 c. m.; soft copper Nos. 3/0 and 4/0, 350,000 c. m., and 500,000 c. m.*

Tension when loaded at 15° F. is 2,000 pounds

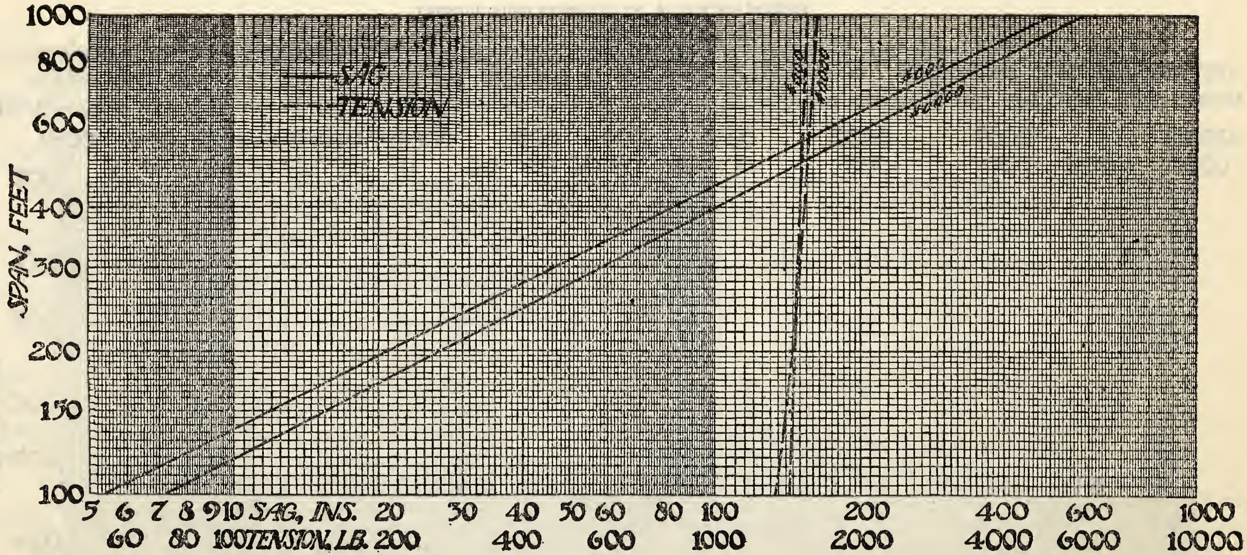

FIG. 10.—*Sags and tensions at 60° F., light loading district. Bare, solid, soft or hard-drawn copper wire, Nos. 3/0 and 4/0*

Tension when loaded at 30° F. is 2,000 pounds

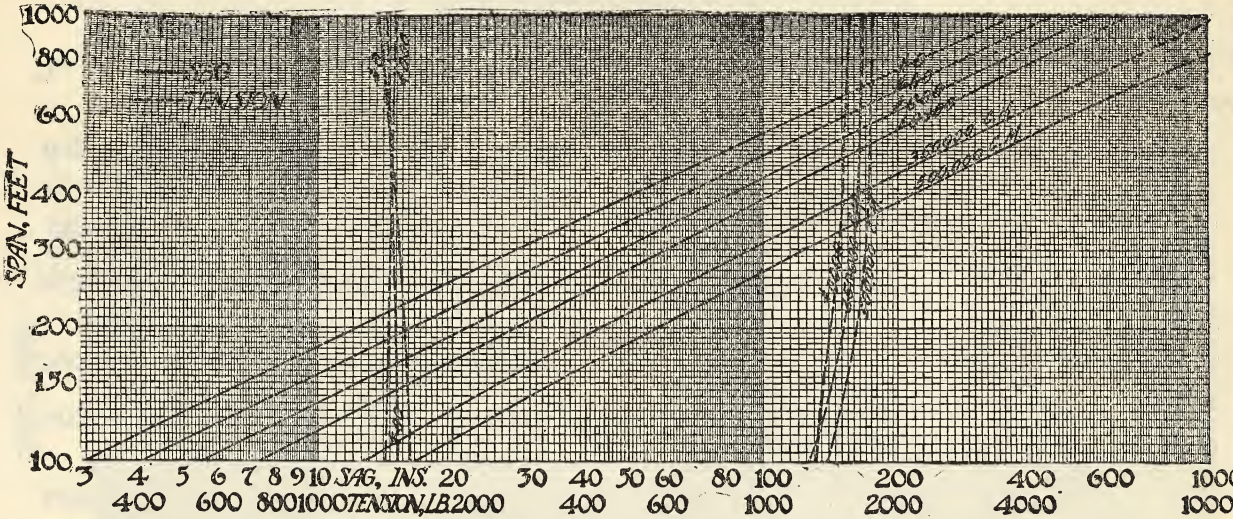

FIG. 11.—*Sags and tensions at 60° F., light loading district. Bare, stranded, hard-drawn copper conductors, Nos. 1/0, 2/0, 3/0, and 4/0, 350,000 c. m., and 500,000 c. m.; soft copper Nos. 3/0 and 4/0, 350,000 c. m., and 500,000 c. m.*

Tension when loaded at 30° F. is 2,000 pounds

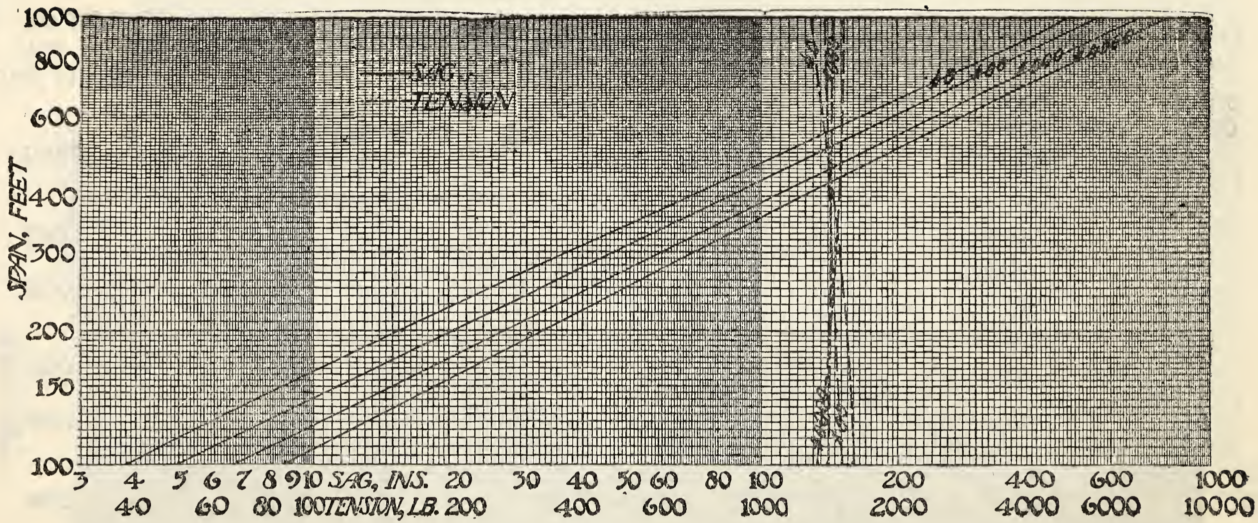

FIG. 12.—*Sags and tensions at 60° F., light loading district. Triple-braid weatherproof, solid, hard-drawn copper wire, Nos. 1/0, 2/0, 3/0, and 4/0; soft copper Nos. 3/0 and 4/0*

Tension when loaded at 30° F. is 2,000 pounds

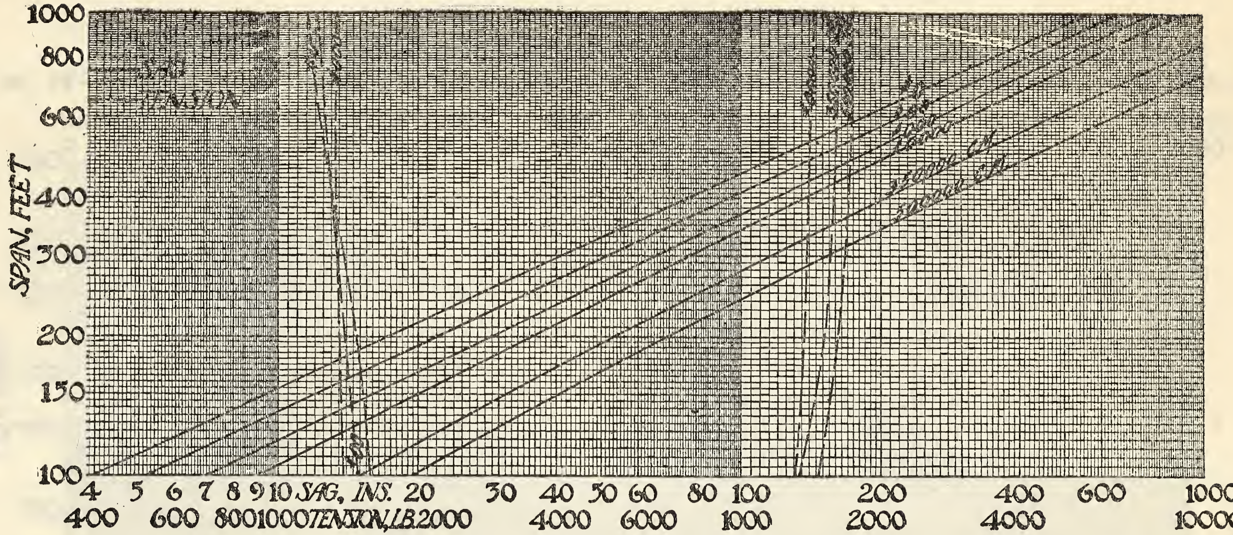

FIG. 13.—*Sags and tensions at 60° F., light loading district. Triple-braid weatherproof, stranded, hard-drawn copper wire, Nos. 1/0, 2/0, 3/0, and 4/0, 350,000 c. m., and 500,000 c. m.; soft copper Nos. 3/0 and 4/0, 350,000 c. m., and 500,000 c. m.*

Tension when loaded at 30° F. is 2,000 pounds

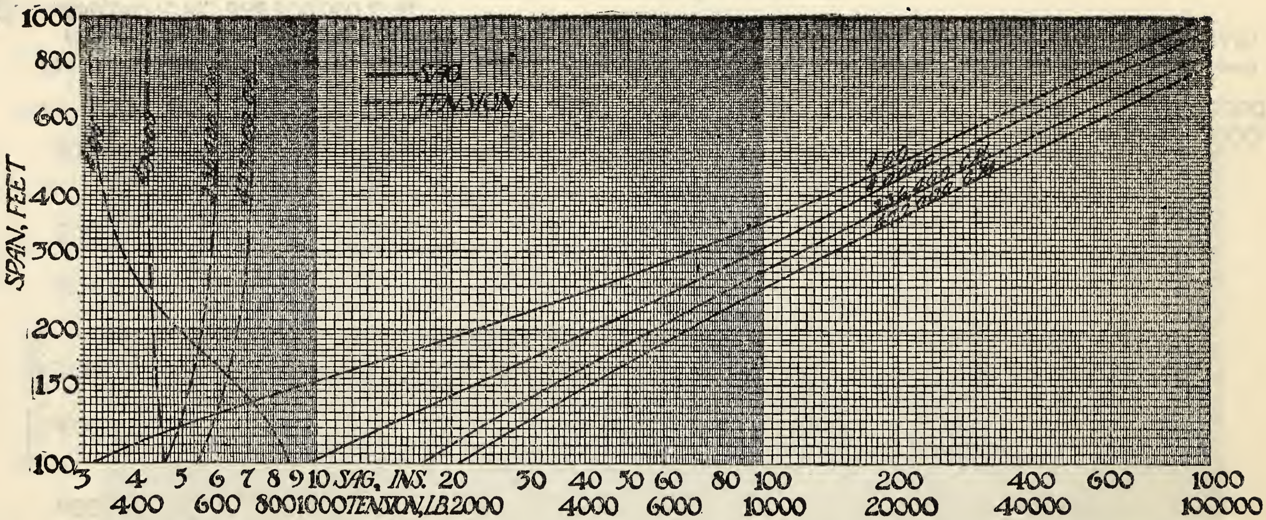

Fig. 14.—*Sags and tensions at 60° F., heavy loading district. Bare, stranded, aluminum conductors, steel-reinforced, Nos. 2/0 and 4/0, 336,400 c. m., and 477,000 c. m.*

Tension when loaded at 0° F. is 2,000 pounds

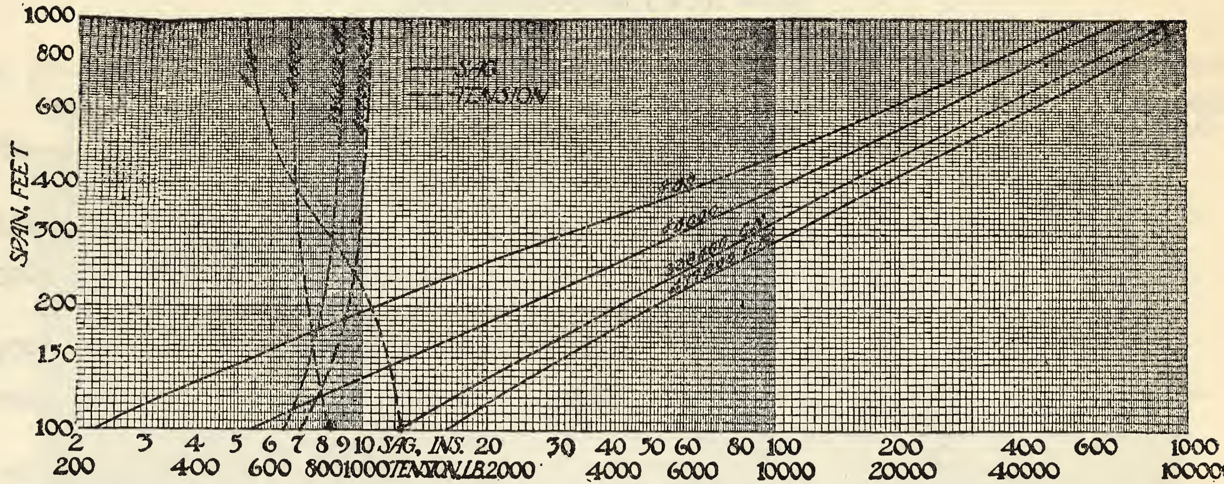

FIG. 15.—*Sags and tensions at 60° F., medium loading district. Bare, stranded, aluminum conductors, steel-reinforced, Nos. 2/0 and 4/0, 336,400 c. m., and 477,000 c. m.*

Tension when loaded at 15° F. is 2,000 pounds

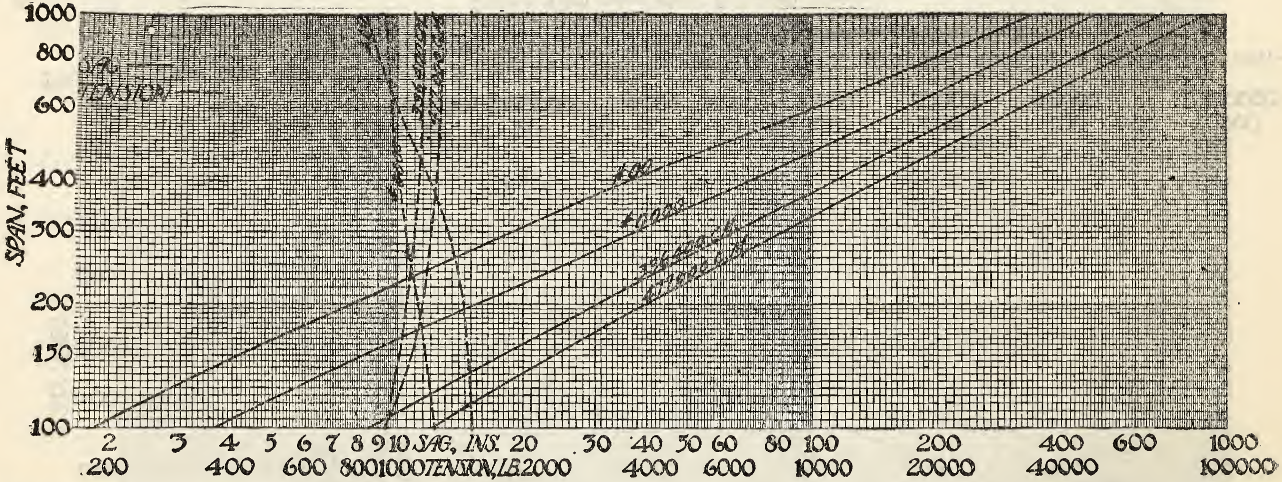

FIG. 16.—*Sags and tensions at 60° F., light loading district. Bare, stranded, aluminum conductors, steel-reinforced, Nos. 2/0 and 4/0, 336,400 c. m., and 477,000 c. m.*

Tension when loaded at 30° F. is 2,000 pounds

Appendix D.—MECHANICAL DATA FOR WIRES AND CABLES

Copper.

The following tables give the mechanical characteristics of copper wire and cable and are based on the standard specifications of the American Society for Testing Materials.

Hard-drawn copper manufactured in accordance with these specifications has an elastic limit of approximately 55 per cent of the ultimate strength given. Soft copper has no definite elastic limit, but it is below 5,000 pounds per square inch. It is not customarily stressed in excess of half its ultimate stress.

For purposes of calculation of sags and stresses, medium hard-drawn wire conforming with the A. S. T. M. specifications is considered as hard-drawn. The breaking load of stranded cable has been taken as 90 per cent of the sum of the breaking loads of the individual strands.

The modulus of elasticity has been taken at 16,000,000 pounds per square inch for all grades of copper. The coefficient of linear thermal expansion per degree Fahrenheit has been taken as 9.6×10^{-6}. The weight of bare solid copper conductors has been taken as 3.854 pounds per square inch of cross section per foot of length; and of stranded conductors as 3.931 pounds. The weights of covered conductors are given in Table 81.

Table 72.—Solid Copper Wire

Size A. W. G. No.	Diameter	Area of conductor	Hard-drawn wire: Ultimate stress	Hard-drawn wire: Breaking load	Soft wire: Ultimate stress	Soft wire: Breaking load
	Inch	*Sq. in.*	*Lbs./in.*^{2}	*Pounds*	*Lbs./in.*^{2}	*Pounds*
0000	0.460	0.166	49,000	8,100	36,000	6,000
000	.410	.132	51,000	6,700	36,000	4,700
00	.365	.104	52,800	5,500	36,000	3,800
0	.325	.083	54,500	4,500	36,000	3,000
1	.289	.066	56,100	3,700	37,000	2,400
2	.258	.052	57,600	3,000	37,000	1,900
3	.229	.041	59,000	2,400	37,000	1,500
4	.204	.033	60,100	2,000	37,000	1,200
6	.162	.021	62,100	1,300	37,000	760
8	.128	.013	63,700	830	37,000	480
9	.114	.010	64,300	660	37,000	370
10	.102	.0082	64,900	530	38,500	310
12	.081	.0051	65,700	340	----------	----------
14	.064	.0032	66,200	210	----------	----------

Table 73.—Stranded Copper Conductors

Size	External diameter	Stranding	Area of conductors	Breaking load: Hard-drawn	Breaking load: Soft
Circular mills:	*Inches*		*Sq. in.*	*Pounds*	*Pounds*
1,000,000	1.15	61×0.128	0.785	45,000	----------
500,000	.813	37× .116	.392	22,700	13,000
450,000	.772	37× .110	.353	20,500	11,700
400,000	.728	37× .104	.314	18,300	10,500
350,000	.681	37× .097	.275	16,100	9,500
350,000	.678	19× .136	.275	15,700	9,100
300,000	.630	37× .090	.236	13,900	8,200
300,000	.628	19× .126	.236	13,500	7,800
250,000	.575	37× .082	.196	11,600	6,800
250,000	.573	19× .115	.196	11,300	6,500
A. W. G. No.:					
0000	.528	19× .106	.166	9,700	5,500
0000	.522	7× .174	.166	9,200	5,500
000	.470	19× .094	.132	7,700	4,600
000	.464	7× .155	.132	7,400	4,400
00	.418	19× .084	.104	6,100	3,600
00	.414	7× .138	.104	5,900	3,500
0	.373	19× .075	.083	4,900	2,850
0	.368	7× .123	.083	4,800	2,750
1	.332	19× .066	.066	3,900	2,300
1	.328	7× .109	.066	3,800	2,200
2	.292	7× .097	.052	3,050	1,800
3	.260	7× .087	.041	2,450	1,430
4	.232	7× .077	.033	1,950	1,130
5	.207	7× .069	.026	1,550	900
6	.184	7× .061	.021	1,230	710
7	.165	7× .055	.016	980	550
8	.146	7× .049	.013	780	450

Steel.

Tables 74 and 75 give the mechanical characteristics of steel wire and cable of three grades, ordinary, Siemens-Martin, and high-tension. The ultimate stresses of the three are taken as 60,000, 75,000, and 125,000 pounds per square inch, respectively. The breaking load of stranded cable has in all cases been taken as 90 per cent of the sum of the breaking loads of the individual strands.

The coefficient of linear thermal expansion for steel has been taken as 6.7×10^{-6} per ° F. The modulus of elasticity has been taken as 29,000,000 pounds per square inch for solid wires and 21,000,000 pounds per square inch for cables. The weight of conductor per square inch of cross section is taken as 3.39 pounds per foot of length.

Steel from different sources may differ in physical properties, and when materials are used having properties different from those assumed, loads and sags should be computed from the actual values.

Table 74.—Bare Solid Steel Wires

Size Stl. W. G. No.	Diameter	Area	Breaking load: Ordinary	Breaking load: Siemens-Martin	Breaking load: High-tension steel
	Inch	*Sq. in.*	*Pounds*	*Pounds*	*Pounds*
4	0.225	0.0400	2,400	3,000	5,000
6	.192	.0290	1,740	2,170	3,620
8	.162	.0206	1,240	1,560	2,570

Table 75.—Stranded Bare Steel Conductors

Nominal size (inches)	Diameter	Area	Breaking load: Ordinary	Breaking load: Siemens-Martin	Breaking load: High-tension steel
	Inch	*Sq. in.*	*Pounds*	*Pounds*	*Pounds*
5/8	0.625	0.2356	12,720	15,900	26,500
9/16	.562	.1922	10,380	13,000	21,620
1/2	.500	.1443	7,790	9,740	16,230
7/16	.437	.1204	6,500	8,130	13,540
3/8	.375	.0832	4,490	5,620	9,360
5/16	.312	.0606	3,270	4,090	6,820
1/4	.250	.0352	1,900	2,380	3,960

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Copper-Covered Steel.

Tables 76, 77, and 78 give the mechanical characteristics of copper-covered steel conductors of standard tensile grade and extra-high-tensile grade. The tables were submitted by the Copperweld Steel Co. for copperweld wire, with supporting data. The breaking load of stranded conductors has been taken as 90 per cent of the sum of the breaking loads of the individual strands.

Sags have been computed for standard tensile grade only. The coefficient of linear thermal expansion for these conductors has been taken as 7.2×10^{-6} per ° F. The modulus of elasticity for solid wires has been taken as 20,000,000 pounds per square inch. For stranded cables, the value of the modulus varies with size as follows:

$\frac{5}{8}$ inch diameter, 15,600,000 pounds per square inch.
$\frac{9}{16}$ inch diameter, 16,100,000 pounds per square inch.
$\frac{1}{2}$ inch diameter, 17,000,000 pounds per square inch.
$\frac{7}{16}$ inch diameter, 17,800,000 pounds per square inch.
$\frac{3}{8}$ inch diameter, 18,600,000 pounds per square inch.
$\frac{5}{16}$ inch diameter, 19,500,000 pounds per square inch.

The weight of conductor per square inch of cross section is taken as 3.53 pounds per foot of length.

Table 76.—Solid Bare Copper-Covered Steel Conductors

Size A. W. G. No.	Diameter	Area	Breaking load	
			Standard	Extra-high tensile
	Inch	*Square inch*	*Pounds*	*Pounds*
0000	0.460	0.166	9,850	
000	.410	.132	8,280	
00	.365	.104	6,850	
0	.325	.083	5,700	
1	.289	.066	4,800	
2	.258	.052	4,000	7,300
3	.229	.041	3,200	5,780
4	.204	.033	2,650	4,600
5	.182	.026	2,200	3,640
6	.162	.021	1,800	2,880
7	.144	.016	1,450	2,290
8	.128	.013	1,200	1,820
9	.114	.0103	970	
10	.102	.0082	800	

Table 77.—Stranded Bare Copper-Covered Steel Conductors—Standard Tensile Grade

Size A. W. G. No.	Nominal diameter	Stranding	Area	Breaking load
	Inch		*Square inch*	*Pounds*
	5/8	7 No. 4	0.229	18,550
	9/16	7 No. 5	.182	15,400
0000		7x	.166	14,300
	1/2	7 No. 6	.144	12,600
000		7x	.132	11,640
	7/16	7 No. 7	.114	10,160
00		7x	.105	9,460
	3/8	7 No. 8	.091	8,400
0		7x	.0829	7,780
	11/32	7 No. 9	.0719	6,790
	5/16	7 No. 10	.0571	5,600

x Means special size wire, not an A.W.G. size.

Table 78.—Stranded Bare Copper-Covered Steel Conductors—Extra-High Tensile Grade

Size A. W. G. No.	Nominal diameter	Stranding	Area	Breaking load
	Inch		*Square inch*	*Pounds*
	7/8	19 No. 5	0.495	62,240
	13/16	19 No. 6	.392	49,250
	3/4	19x	.354	44,600
	23/32	19 No. 7	.311	39,160
	11/16	19x	.275	34,800
	5/8	19 No. 8	.246	31,120
	5/8	7 No. 4	.229	28,980
	9/16	7 No. 5	.182	22,930
0000		7x	.166	20,940
	1/2	7 No. 6	.144	18,200
000		7x	.132	16,600
	7/16	7 No. 7	.114	14,420
00		7x	.105	13,160
	3/8	7 No. 8	.091	11,460

x Means special size wire, not an A.W.G. size.

Aluminum.

Table 79 gives the mechanical characteristics of stranded aluminum conductors. The coefficient of linear thermal expansion for aluminum has been taken as 12.8×10^{-6} per degree Fahrenheit, and the modulus of elasticity as 9,000,000 pounds per square inch. The weight of conductor is 1.194 pounds per square inch of cross section for a length of 1 foot.

Table 80 gives the mechanical characteristics of aluminum cable having a steel core. The virtual coefficient of expansion, the modulus of elasticity, and the weight per unit length vary with the size of cable. For cables of sizes 4/0 to 6, A. W. G., the coefficient of thermal expansion has been taken as 10.5×10^{-6} per degree Fahrenheit; the modulus of elasticity as 12,000,000 pounds per square inch; and the weight per unit cross section as 1.52 pounds per foot of length.

Table 79.—Stranded Aluminum Conductors

Size	Diameter	Area	Usual stranding	Copper equivalent	Elastic limit	Breaking load
Circular mils:	*Inches*	*Square inch*		*c. m.*	*Pounds*	*Pounds*
874, 500	1.077	0.687	37×0.154	550, 000	9, 600	14, 800
795, 000	1.026	.624	37× .146	500, 000	8, 750	13, 500
750, 000	.994	.589	37× .142	472, 000	8, 250	12, 700
715, 500	.974	.562	37× .139	450, 000	7, 870	12, 100
636, 000	.918	.500	37× .131	400, 000	7, 000	10, 800
556, 500	.856	.437	19× .171	350, 000	6, 120	9, 450
500, 000	.810	.393	19× .162	314, 500	5, 500	8, 500
477, 000	.793	.375	19× .158	300, 000	5, 240	8, 100
397, 500	.724	.312	19× .145	250, 000	4, 370	6, 750
300, 000	.621	.236	19× .126	188, 800	3, 300	5, 100
				A. W. G. No.		
336, 400	.657	.264	19× .133	4/0	3, 700	5, 700
266, 800	.586	.209	7× .195	3/0	2, 940	4, 550
A. W. G. No.:						
4/0	.522	.166	7× .174	2/0	2, 330	3, 570
3/0	.464	.132	7× .155	0	1, 845	2, 860
2/0	.414	.104	7× .138	1	1, 465	2, 270
0	.368	.083	7× .123	2	1, 160	1, 790
1	.328	.066	7× .109	3	920	1, 420

Table 80.—Aluminum Cables, Steel-Reinforced

Size	Equivalent copper	Diameter	Stranding: Aluminum	Stranding: Steel	Total area	Breaking load
Circular mils:	*c. m.*	*Inches*			*Square inch*	*Pounds*
795, 000	500, 000	1. 093	54×0. 1214	7×0. 1214	0. 7060	25, 150
715, 500	450, 000	1. 036	54× . 1151	7× . 1151	. 6350	22, 680
636, 000	400, 000	. 977	54× . 1085	7× . 1085	. 5640	20, 060
477, 000	300, 000	. 883	30× . 1261	7× . 1261	. 4620	20, 700
397, 500	250, 000	. 806	30× . 1151	7× . 1151	. 3850	17, 250
	A. W. G. No.					
336, 400	0000	. 741	30× . 1059	7× . 1059	. 3260	14, 580
266, 800	000	. 633	6× . 2108	7× . 0705	. 2370	8, 450
A. W. G. No.:						
0000	00	. 564	6× . 1880	1× . 1880	. 1939	7, 590
000	0	. 501	6× . 1670	1× . 1670	. 1537	5, 995
00	1	. 447	6× . 1490	1× . 1490	. 1219	4, 770
0	2	. 398	6× . 1327	1× . 1327	. 0967	3, 780
1	3	. 355	6× . 1182	1× . 1182	. 0766	3, 000
2	4	. 316	6× . 1052	1× . 1052	. 0608	2, 394
3	5	. 281	6× . 0938	1× . 0938	. 0482	1, 890
4	6	. 250	6× . 0834	1× . 0834	. 0383	1, 500
5	7	. 223	6× . 0743	1× . 0743	. 0303	1, 183
6	8	. 198	6× . 0661	1× . 0661	. 0240	940

The values given in these tables were submitted by the Aluminum Co. of America with supporting data. The breaking load of stranded conductors has been taken as 90 per cent of the sum of the breaking loads of the individual strands, including the steel core where used.

Appendix E.—LOADS UPON CONDUCTORS AND SUPPORTS

Table 81 gives the weights of conductors of various sizes and materials, with and without ice loading. Table 82 gives the transverse and resultant loads of the same conductors based on the assumed loadings of section 25. The over-all diameters of covered wires supplied by different manufacturers are not the same and hence average values have been chosen. This is also true of the sizes of strands which make up steel cables.

Table 81.—Vertical Loads on Conductor Supports

Size of conductor	Diameter over all	Weight of— Conductor +0.5 inch of ice=heavy	Conductor +0.25 inch of ice=medium	Conductor only=light
Bare solid copper:				
A. W. G. No.—	*Inch*	*Lbs./ft.*	*Lbs./ft.*	*Lbs./ft.*
12	0.081	0.381	0.122	0.020
10	.102	.406	.141	.031
8	.128	.440	.168	.050
6	.162	.491	.207	.079
4	.204	.564	.268	.126
3	.229	.612	.308	.159
2	.258	.672	.359	.201
1	.289	.744	.421	.253
0	.325	.832	.498	.319
00	.365	.943	.596	.405
000	.410	1.075	.714	.509
0000	.460	1.237	.861	.640
Bare stranded copper:				
A. W. G. No.—				
6	.18	.505	.216	.083
4	.23	.580	.275	.126
3	.26	.634	.320	.161
2	.29	.696	.372	.204
1	.33	.775	.440	.259
0	.37	.867	.519	.326
00	.41	.979	.618	.413
000	.46	1.116	.740	.519
0000	.52	1.287	.892	.652

Table 81.—Vertical Loads on Conductor Supports—Continued

Size of conductor	Diameter over all	Weight of— Conductor +0.5 inch of ice = heavy	Conductor +0.25 inch of ice = medium	Conductor only = light
Bare stranded copper—Continued.				
Cir. mils—	*Inch*	*Lbs./ft.*	*Lbs./ft.*	*Lbs./ft.*
250,000	0.57	1.436	1.025	0.770
300,000	.63	1.630	1.201	.928
350,000	.68	1.815	1.370	1.081
400,000	.73	1.992	1.539	1.234
450,000	.77	2.177	1.705	1.388
500,000	.81	2.355	1.870	1.541
1,000,000	1.15	4.112	3.521	3.086
T. B. W. P. solid copper:				
A. W. G. No.—				
12	.21	.476	.178	.035
10	.25	.519	.208	.053
8	.26	.547	.234	.075
6	.32	.622	.289	.112
4	.38	.711	.370	.164
3	.41	.760	.405	.200
2	.44	.840	.474	.260
1	.47	.919	.540	.316
0	.50	1.029	.640	.407
00	.53	1.143	.745	.502
000	.62	1.326	.900	.630
0000	.65	1.482	1.047	.767
T. B. W. P. stranded copper:				
A. W. G. No.—				
2	.444	.857	.486	.270
1	.518	.961	.567	.328
0	.620	1.120	.694	.424
00	.662	1.245	.806	.522
000	.734	1.421	.960	.654
0000	.785	1.599	1.122	.800
Cir. mils—				
250,000	.862	1.832	1.331	.985
350,000	.978	2.264	1.727	1.345
500,000	1.108	2.894	2.316	1.894
750,000	1.343	3.968	3.317	2.822
1,000,000	1.531	4.937	4.228	3.674
Bare solid steel:				
Stl. W. G. No.—				
8	.162	.482	.198	.070
6	.192	.528	.235	.098
4	.225	.586	.283	.135
Bare stranded steel:				
¼-inch	.250	.586	.275	.119
5/16-inch	.312	.711	.380	.205
⅜-inch	.375	.826	.476	.282
7/16-inch	.437	.991	.622	.408
½-inch	.500	1.111	.722	.489
9/16-inch	.562	1.312	.904	.652
⅝-inch	.625	1.498	1.071	.799

Table 81.—Vertical Loads on Conductor Supports—Continued

Size of conductor	Diameter over all	Weight of— Conductor +0.5 inch of ice = heavy	Conductor +0.25 inch of ice = medium	Conductor only = light
Solid bare copper-covered steel:				
A. W. G. No.—	*Inch*	*Lbs./ft.*	*Lbs./ft.*	*Lbs./ft.*
10	0.102	0.402	0.138	0.029
8	.128	.437	.163	.046
6	.162	.485	.201	.073
4	.204	.554	.257	.116
Stranded bare copper-covered steel:				
5/16-inch	.306	.710	.382	.209
3/8-inch	.384	.882	.529	.332
7/16-inch	.432	.998	.630	.418
1/2-inch	.486	1.139	.755	.526
9/16-inch	.546	1.313	.910	.663
Stranded aluminum, bare:				
A. W. G. No.—				
2	.293	.554	.230	.062
1	.328	.592	.258	.079
0	.368	.637	.290	.099
00	.414	.692	.331	.125
000	.464	.756	.379	.158
0000	.522	.832	.437	.198
Bare stranded aluminum, steel-reinforced:				
A. W. G. No.—				
4	.250	.523	.213	.058
2	.316	.598	.268	.092
1	.355	.647	.305	.117
0	.398	.704	.348	.147
00	.447	.772	.401	.185
000	.501	.853	.465	.232
0000	.564	.954	.547	.294
Cir. mils—				
336,400	.741	1.297	.834	.527
477,000	.883	1.605	1.098	.747

Table 82.—Transverse and Resultant Loads on Conductors and Supports in Three Loading Districts

[Pounds per conductor per linear foot]

Size of conductor	Transverse force on conductor with ice covering (if any)			Resultant force on conductor due to weight and wind		
	Heavy	Medium	Light	Heavy	Medium	Light
Bare solid copper:						
A. W. G. No.—						
12	0.721	0.387	0.081	0.815	0.406	0.084
10	.735	.401	.102	.840	.425	.107
8	.752	.419	.128	.872	.451	.137
6	.775	.442	.162	.918	.467	.180

Table 82.—Transverse and Resultant Loads on Conductors and Supports in Three Loading Districts—Continued

[Pounds per conductor per linear foot]

Size of conductor	Transverse force on conductor with ice covering (if any)			Resultant force on conductor due to weight and wind		
	Heavy	Medium	Light	Heavy	Medium	Light
Bare solid copper—Contd.						
A. W. G. No.—						
4	0.803	0.470	0.204	0.986	0.540	0.240
3	.820	.486	.229	1.023	.576	.279
2	.839	.506	.258	1.075	.620	.327
1	.860	.526	.289	1.137	.674	.384
0	.884	.550	.325	1.214	.742	.456
00	.910	.577	.365	1.310	.829	.545
000	.940	.607	.410	1.428	.937	.653
0000	.974	.640	.460	1.574	1.073	.788
Bare stranded copper:						
A. W. G. No.—						
6	.787	.454	.180	.935	.503	.198
4	.820	.487	.230	1.005	.559	.262
3	.840	.507	.260	1.053	.599	.306
2	.860	.527	.290	1.106	.645	.355
1	.887	.554	.330	1.178	.707	.420
0	.914	.580	.370	1.260	.779	.493
00	.940	.607	.410	1.357	.866	.582
000	.974	.640	.460	1.481	.978	.693
0000	1.014	.680	.520	1.638	1.122	.834
Cir. mils—						
250,000	1.047	.714	.570	1.777	1.294	.958
300,000	1.087	.754	.630	1.960	1.418	1.121
350,000	1.121	.787	.680	2.133	1.580	1.277
400,000	1.154	.820	.730	2.308	1.744	1.434
450,000	1.181	.847	.770	2.477	1.904	1.587
500,000	1.207	.874	.810	2.646	2.064	1.741
1,000,000	1.434	1.100	1.150	4.355	3.822	3.293
T. B. W. P. solid copper:						
A. W. G. No.—						
12	.807	.474	.210	.937	.506	.213
10	.834	.500	.250	.987	.542	.255
8	.840	.507	.260	1.003	.558	.270
6	.880	.547	.320	1.078	.619	.339
4	.920	.587	.380	1.163	.694	.414
3	.940	.607	.410	1.213	.730	.456
2	.960	.627	.440	1.276	.768	.511
1	.980	.647	.470	1.344	.843	.566
0	1.000	.667	.500	1.435	.924	.645
00	1.020	.687	.530	1.532	1.013	.730
000	1.080	.747	.620	1.711	1.170	.872
0000	1.100	.767	.650	1.846	1.286	1.005
T. B. W. P. stranded copper:						
A. W. G. No.—						
2	.961	.630	.444	1.289	.796	.520
1	1.012	.679	.518	1.396	.884	.613
0	1.080	.747	.620	1.557	1.020	.751
00	1.109	.775	.662	1.667	1.118	.843
000	1.157	.823	.734	1.832	1.331	.983
0000	1.191	.857	.785	1.994	1.412	1.121

Table 82.—Transverse and Resultant Loads on Conductors and Supports in Three Loading Districts—Continued

[Pounds per conductor per linear foot]

Size of conductor	Transverse force on conductor with ice covering (if any)			Resultant force on conductor due to weight and wind		
	Heavy	Medium	Light	Heavy	Medium	Light
T. B. W. P. stranded copper—Continued.						
Cir. mils—						
250,000	1.241	0.908	0.862	2.213	1.611	1.309
350,000	1.319	.986	.978	2.620	1.988	1.663
500,000	1.406	1.072	1.108	3.217	2.552	2.194
750,000	1.563	1.229	1.343	4.265	3.538	3.125
1,000,000	1.688	1.355	1.531	5.218	4.439	3.980
Bare solid steel:						
Stl. W. G. No.—						
8	.775	.442	.162	.912	.484	.176
6	.795	.462	.192	.955	.518	.216
4	.817	.484	.225	1.006	.560	.263
Bare stranded steel:						
¼-inch	.833	.500	.250	1.018	.570	.277
5/16-inch	.875	.542	.312	1.126	.661	.374
⅜-inch	.917	.583	.375	1.234	.753	.469
7/16-inch	.958	.625	.437	1.379	.882	.598
½-inch	1.000	.667	.500	1.495	.983	.699
9/16-inch	1.042	.708	.562	1.675	1.149	.861
⅝-inch	1.083	.750	.625	1.849	1.307	1.014
Solid bare copper-covered steel:						
A. W. G. No.—						
10	.735	.401	.102	.838	.425	.106
8	.752	.419	.128	.870	.450	.136
6	.775	.442	.162	.914	.485	.178
4	.803	.470	.204	.975	.535	.235
Stranded bare copper-covered steel:						
5/16-inch	.871	.538	.306	1.124	.659	.370
⅜-inch	.923	.590	.384	1.276	.792	.508
7/16-inch	.955	.622	.432	1.381	.885	.601
½-inch	.991	.658	.486	1.510	1.001	.716
9/16-inch	1.031	.698	.546	1.670	1.147	.859
Bare stranded aluminum:						
A. W. G. No.—						
2	.862	.529	.293	1.020	.577	.300
1	.886	.552	.328	1.065	.609	.337
0	.912	.579	.368	1.113	.647	.380
00	.943	.610	.414	1.170	.693	.432
000	.976	.643	.464	1.234	.746	.489
0000	1.015	.682	.522	1.312	.810	.557
Bare stranded aluminum steel-reinforced:						
A. W. G. No.—						
4	.834	.500	.250	.984	.544	.257
2	.878	.544	.316	1.062	.607	.329
1	.904	.570	.355	1.112	.646	.374
0	.932	.599	.398	1.168	.693	.424
00	.965	.632	.447	1.236	.748	.484
000	1.001	.668	.501	1.315	.814	.552
0000	1.043	.710	.564	1.414	.896	.636
Cir. mils—						
336,400	1.161	.828	.741	1.741	1.175	.909
477,000	1.256	.922	.883	2.038	1.434	1.157

Appendix F.—WOOD POLES

Moments of Resistance of Poles.

The resisting moments of wood poles of various ground-line circumferences are given in the accompanying tables for each value of allowable fiber stress recognized in Table 21 (rule 261A, 4) for poles when installed. Table 83 gives the values for dense southern yellow pine; Table 84 for other pine, chestnut, western cedar, cypress, etc., having a recognized ultimate fiber stress of 5,000 pounds per square inch; and Table 85 for woods having an ultimate fiber stress of 3,600 pounds per square inch, such as redwood and eastern cedar (northern white cedar).

Southern yellow pine should not be used for supporting structures unless first given a preservative treatment, as otherwise the rapid deterioration will require early replacement.

The following formula has been used in calculating the moments:

$M = 0.0002638\, f\, C^3$ = moment in pound-feet; where

f = allowable fiber stress in pounds per square inch, and

C = circumference of the pole at ground line in inches.

While the ground-line section may not be the most stressed section in poles with considerable taper, it is so regarded here. Since the wood usually deteriorates most rapidly at this point, it is here that sufficient strength must be provided.

Table 83.—Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 6,500 Pounds per Square Inch (Dense Southern Yellow Pine)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)					
	2,170	2,600	3,250	3,900	4,870	6,500
	Lb.-ft.	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*
24	7,900	9,500	11,850	14,200	17,750	23,700
25	8,950	10,700	13,400	16,100	20,050	26,800
26	10,050	12,050	15,050	18,100	22,600	30,150
27	11,250	13,500	16,900	20,250	25,300	33,750
28	12,550	15,050	18,800	22,600	28,200	37,650
29	13,950	16,750	20,900	25,100	31,350	41,800
30	15,450	18,500	23,150	27,800	34,700	46,300
31	17,050	20,450	25,550	30,650	38,250	51,100
32	18,750	22,500	28,100	33,700	42,100	56,200
33	20,550	24,650	30,800	36,950	46,150	61,600
34	22,500	26,950	33,700	40,450	50,500	67,400
35	24,550	29,400	36,750	44,100	55,100	73,500
36	26,700	32,000	40,000	48,000	59,950	80,000
37	29,000	34,750	43,400	52,100	65,050	86,850
38	31,400	37,650	47,050	56,450	70,500	94,100
39	33,950	40,700	50,850	61,050	76,200	101,700
40	36,650	43,900	54,850	65,850	82,200	109,750
41	39,450	47,250	59,100	70,900	88,550	118,200
42	42,400	50,800	63,500	76,200	95,200	127,050
43	45,500	54,550	68,150	81,800	102,150	136,350
44	48,750	58,450	73,050	87,650	109,450	146,050
45	52,150	62,500	78,150	93,750	117,050	156,250
46	55,700	66,750	83,450	100,150	125,050	166,900
47	59,450	71,200	89,000	106,800	133,400	178,000
48	63,300	75,850	94,800	113,800	142,100	189,650
49	67,350	80,700	100,850	121,050	151,150	201,750
50	71,550	85,750	107,150	128,600	160,600	214,350
51	75,950	91,000	113,750	136,450	170,400	227,450
52	80,500	96,450	120,550	144,650	180,650	241,100
53	85,200	102,100	127,650	153,150	191,250	255,300
54	90,150	108,000	135,000	162,000	202,300	270,000
55	95,250	114,100	142,650	171,150	213,750	285,300
56	100,550	120,450	150,550	180,700	225,600	301,150
57	106,000	127,000	158,800	190,550	237,900	317,550
58	111,700	133,800	167,300	200,750	250,650	334,550
59	117,550	140,850	176,100	211,300	263,850	352,150
60	123,650	148,150	185,200	222,200	277,500	370,400
61	129,950	155,700	194,600	233,500	291,600	389,200
62	136,450	163,450	204,350	245,200	306,200	408,650
63	143,150	171,500	214,400	257,250	321,250	428,750

Table 83.—Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 6,500 Pounds per Square Inch (Dense Southern Yellow Pine—Continued)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)					
	2,170	2,600	3,250	3,900	4,870	6,500
	Lb.-ft.	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*
64	150,050	179,800	224,750	269,700	336,800	449,500
65	157,200	188,350	235,450	282,550	352,800	470,900
66	164,600	197,200	246,500	295,800	369,350	492,950
67	172,150	206,300	257,850	309,450	386,400	515,700
68	180,000	215,050	269,600	323,500	403,950	539,150
69	188,050	225,300	281,650	338,000	422,050	563,300
70	196,350	235,250	294,050	352,900	440,650	588,150
71	204,900	245,500	306,850	368,250	459,800	613,700
72	213,650	256,000	320,000	384,000	479,500	640,000
73	222,700	266,800	335,500	400,250	499,750	667,050
74	231,950	277,950	347,400	416,900	520,600	694,850
75	241,500	289,350	361,700	434,050	542,000	723,400

Table 84.—Resisting Moments for Poles of Woods with Ultimate Fiber Stress of 5,000 Pounds per Square Inch (Pine, Chestnut, Western Cedar, Cypress, etc.)

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)—						
	1,250	1,670	2,000	2,500	3,000	3,750	5,000
	Lb.-ft.	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*
24	4,550	6,100	7,300	9,100	10,950	13,700	18,250
25	5,150	6,900	8,250	10,300	12,350	15,450	20,600
26	5,800	7,750	9,250	11,600	13,900	17,400	23,200
27	6,500	8,650	10,400	13,000	15,600	19,450	25,950
28	7,250	9,650	11,600	14,500	17,350	21,700	28,950
29	8,050	10,750	12,850	16,100	19,300	24,150	32,150
30	8,900	11,900	14,250	17,800	21,350	26,700	35,600
31	9,800	13,100	15,700	19,650	23,600	29,450	39,300
32	10,800	14,450	17,300	21,600	25,950	32,400	43,200
33	11,850	15,850	18,950	23,700	28,450	35,550	47,400
34	12,950	17,300	20,750	25,900	31,100	38,900	51,850
35	14,150	18,900	22,600	28,300	33,950	42,400	56,550
36	15,400	20,550	24,600	30,750	36,900	46,150	61,550
37	16,700	22,300	26,700	33,400	40,100	50,100	66,800
38	18,100	24,150	28,950	36,200	43,450	54,300	72,400
39	19,550	26,150	31,300	39,100	46,950	58,700	78,250

Table 84.—Resisting Moments for Poles of Woods with Ultimate Fiber Stress of 5,000 Pounds per Square Inch (Pine, Chestnut, Western Cedar, Cypress, etc.)—Continued

Circumference at ground line (inches)	Resisting moments for fiber stress of (pounds per square inch)—						
	1,250	1,670	2,000	2,500	3,000	3,750	5,000
	Lb.-ft.	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*
40	21, 100	28, 200	33, 750	42, 200	50, 650	63, 300	84, 400
41	22, 750	30, 350	36, 350	45, 450	54, 550	68, 200	90, 900
42	24, 450	32, 650	39, 100	48, 850	58, 650	73, 300	97, 700
43	26, 200	35, 050	41, 950	52, 450	62, 900	78, 650	104, 850
44	28, 100	37, 550	44, 950	56, 200	67, 400	84, 250	112, 350
45	30, 050	40, 150	48, 100	60, 100	72, 100	90, 150	120, 200
46	32, 100	42, 900	51, 350	64, 200	77, 050	96, 300	128, 400
47	34, 250	45, 750	54, 800	68, 500	82, 150	102, 700	136, 950
48	36, 450	48, 700	58, 350	72, 950	87, 500	109, 400	145, 850
49	38, 800	51, 850	62, 050	77, 600	93, 100	116, 400	155, 200
50	41, 200	55, 050	65, 950	82, 450	98, 900	123, 650	164, 900
51	43, 750	58, 450	70, 000	87, 500	105, 000	132, 200	174, 950
52	46, 350	61, 950	74, 200	92, 750	111, 300	139, 100	185, 450
53	49, 100	65, 600	78, 550	98, 200	117, 800	147, 300	196, 350
54	51, 900	69, 350	83, 100	103, 850	124, 600	155, 750	207, 700
55	54, 850	73, 300	87, 800	109, 700	131, 650	164, 600	219, 450
56	57, 900	77, 350	92, 650	115, 800	139, 000	173, 750	231, 650
57	61, 050	81, 600	97, 700	122, 150	146, 550	183, 200	244, 250
58	64, 350	85, 950	102, 950	128, 700	154, 400	193, 000	257, 350
59	67, 700	90, 500	108, 350	135, 450	162, 550	203, 150	270, 900
60	71, 250	95, 150	113, 900	142, 450	170, 950	213, 700	284, 900
61	74, 850	100, 000	119, 750	149, 700	179, 650	224, 550	299, 400
62	78, 600	104, 500	125, 750	157, 200	188, 600	235, 750	314, 350
63	82, 450	110, 150	131, 900	164, 900	197, 900	247, 350	329, 800
64	86, 450	115, 500	138, 300	172, 900	207, 450	259, 350	345, 750
65	90, 550	121, 000	144, 900	181, 100	217, 350	271, 650	362, 250
66	94, 800	126, 650	151, 700	189, 600	227, 500	284, 400	379, 200
67	99, 200	132, 500	158, 700	198, 350	238, 000	297, 550	396, 700
68	103, 700	138, 500	165, 900	207, 350	248, 850	311, 050	414, 750
69	108, 350	144, 700	173, 300	216, 650	260, 000	325, 000	433, 300
70	113, 100	151, 100	180, 950	226, 200	271, 450	339, 300	452, 400
71	118, 000	157, 700	188, 850	236, 050	283, 250	354, 050	472, 100
72	123, 100	164, 450	196, 950	246, 150	295, 400	369, 250	492, 300
73	128, 250	171, 400	205, 250	256, 550	307, 850	384, 850	513, 100
74	133, 600	178, 500	213, 800	267, 250	320, 700	400, 850	534, 500
75	139, 100	185, 850	222, 600	278, 250	333, 850	417, 300	556, 450

Table 85.—Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 3,600 Pounds per Square Inch (Eastern Cedar, Redwood, etc.)

Circumference at ground line (inches)	Resisting moment for fiber stress of (pounds per square inch)—						
	900	1,200	1,440	1,800	2,160	2,700	3,600
	Lb.-ft.	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*
24	3,300	4,400	5,250	6,550	7,900	9,850	13,150
25	3,700	4,950	5,950	7,400	8,900	11,150	14,850
26	4,150	5,550	6,700	8,350	10,000	12,500	16,700
27	4,650	6,250	7,500	9,350	11,200	14,000	18,700
28	5,200	6,950	8,350	10,400	12,500	15,650	20,850
29	5,800	7,700	9,250	11,600	13,900	17,350	23,150
30	6,400	8,550	10,250	12,800	15,400	19,250	25,650
31	7,050	9,450	11,300	14,150	17,000	21,200	28,300
32	7,800	10,350	12,450	15,550	18,650	23,350	31,100
33	8,550	11,400	13,650	17,050	20,500	25,600	34,150
34	9,350	12,450	14,950	18,650	22,400	28,000	37,350
35	10,200	13,550	16,300	20,350	24,450	30,550	40,700
36	11,100	14,750	17,700	22,150	26,600	33,250	44,300
37	12,050	16,050	19,250	24,050	28,850	36,100	48,100
38	13,050	17,350	20,850	26,050	31,250	39,100	52,100
39	14,100	18,800	22,550	28,150	33,800	42,250	56,350
40	15,200	20,250	24,300	30,400	36,450	45,600	60,800
41	16,350	21,800	26,200	32,750	39,250	49,100	65,450
42	17,600	23,450	28,150	35,200	42,200	52,750	70,350
43	18,900	25,150	30,200	37,750	45,300	56,650	75,500
44	20,200	26,950	32,350	40,450	48,550	60,650	80,900
45	21,650	28,850	34,600	43,250	51,900	64,900	86,550
46	23,100	30,800	37,000	46,200	55,450	69,350	92,450
47	24,650	32,850	39,450	49,300	59,150	73,950	98,600
48	26,250	35,000	42,000	52,500	63,000	78,750	105,050
49	27,950	37,250	44,700	55,850	67,050	83,800	111,750
50	29,700	39,550	47,500	59,350	71,250	89,050	118,700
51	31,500	42,000	50,400	63,000	75,600	94,500	126,000
52	33,400	44,500	53,400	66,750	80,100	100,150	133,550
53	35,350	47,150	56,550	70,700	84,850	106,050	141,400
54	37,400	49,850	59,800	74,750	89,700	112,150	149,550
55	39,500	52,650	63,200	79,000	94,800	118,500	158,000
56	41,700	55,600	66,700	83,400	100,050	125,100	166,800
57	43,950	58,600	70,350	87,950	105,500	131,900	175,850
58	46,300	61,750	74,100	92,650	111,200	138,950	185,300
59	48,750	65,000	78,000	97,500	117,500	146,300	195,050
60	51,300	68,400	82,050	102,550	123,100	153,850	205,150
61	53,900	71,850	86,200	107,800	129,350	161,650	215,550
62	56,600	75,450	90,550	113,150	135,800	169,750	226,350
63	59,350	79,150	95,000	118,750	142,500	178,100	237,450
64	62,250	83,000	99,600	124,500	149,350	186,700	248,950
65	65,200	86,950	104,300	130,400	156,900	195,600	260,800
66	68,250	91,000	109,200	136,500	163,800	204,750	273,050
67	71,400	95,200	114,250	142,800	171,400	214,200	285,650

Table 85.—Resisting Moments for Poles of Woods Having Ultimate Fiber Stress of 3,600 Pounds per Square Inch (Eastern Cedar, Redwood, etc.)—Continued

Circumference at ground line (inches)	Resisting moment for fiber stress of (pounds per square inch)—						
	900	1,200	1,440	1,800	2,160	2,700	3,600
	Lb.-ft.	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*	*Lb.-ft.*
68	74,650	99,550	119,450	149,300	179,150	223,950	298,600
69	78,000	104,000	124,800	156,000	187,200	234,000	312,000
70	81,450	108,600	130,300	162,850	195,450	244,300	325,750
71	85,000	113,300	135,950	169,950	203,950	255,000	339,900
72	88,600	118,150	141,800	177,250	212,700	265,850	354,450
73	92,350	123,150	147,800	184,700	221,650	277,100	369,450
74	96,200	128,300	153,950	192,400	230,900	288,600	384,850
75	100,150	133,550	160,250	200,300	240,400	300,500	400,650

Depreciation of Wood Poles.

Rule 261, A, 4 stipulates that wood poles shall be of such material and dimensions that the loading specified in section 25 will not cause the fiber stresses given in Table 20 to be exceeded. The allowable fiber stresses vary with the grade of construction, and even with a stated grade of construction vary according to the situation and according to whether the pole has had previous preservative treatment. When the pole has deteriorated to such an extent that the fiber stress reaches another specified value, the pole must be replaced. The percentage of depreciation varies with the conditions. Table 86 gives the minimum permissible depreciated ground-line circumference for poles which have just met the requirements when installed. Table 88 gives the same information in terms of the permissible reduction in the radius of the cross section of the pole taken at the ground line. Table 87 shows the situations to which the various values in Tables 86 and 88 apply.

Table 86.—Minimum Depreciated Ground-Line Circumference of Wood Poles

Ground-line circumference when installed (inches)	Minimum allowable depreciated ground-line circumference for ratio of fiber stress when installed to fiber stress when depreciated of—					
	2/3	3/5	5/9	1/2	4/9	2/5
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
24	21.0	20.2	19.7	19.0	18.3	17.7
25	21.8	21.1	20.6	19.8	19.1	18.4
26	22.7	21.9	21.5	20.6	19.8	19.2
27	23.6	22.8	22.2	21.4	20.6	19.9
28	24.5	23.6	23.0	22.2	21.4	20.6
29	25.3	24.5	23.8	23.0	22.1	21.4
30	26.2	25.3	24.7	23.8	22.9	22.1
31	27.1	26.1	25.5	24.6	23.7	22.8
32	28.0	27.0	26.3	25.4	24.4	23.6
33	28.8	28.0	27.1	26.2	25.2	24.3
34	29.7	28.7	28.0	27.0	25.9	25.0
35	30.6	29.5	28.8	27.8	26.7	25.8
36	31.4	30.4	29.6	28.6	27.5	26.5
37	32.3	31.2	30.4	29.4	28.2	27.3
38	33.2	32.0	31.2	30.2	29.0	28.0
39	34.1	32.9	32.1	30.9	29.8	28.7
40	34.9	33.7	32.9	31.7	30.5	29.5
41	35.8	34.6	33.7	32.5	31.3	30.2
42	36.7	35.4	34.5	33.3	32.1	31.0
43	37.6	36.3	35.4	34.1	32.8	31.7
44	38.4	37.1	36.2	34.9	33.6	32.4
45	39.3	38.0	37.0	35.7	34.3	33.2
46	40.2	38.8	37.8	36.5	35.1	33.9
47	41.1	39.6	38.6	37.3	35.9	34.6
48	41.9	40.5	39.5	38.1	36.6	35.4
49	42.8	41.3	40.3	38.9	37.4	36.1
50	43.7	42.4	41.1	39.7	38.2	36.8
51	44.5	43.0	41.9	40.5	38.9	37.6
52	45.4	43.7	42.7	41.3	39.7	38.3
53	46.3	44.7	43.6	42.1	40.4	39.0
54	47.2	45.5	44.4	42.9	41.2	39.8
55	48.0	46.4	45.2	43.7	42.0	40.5
56	48.9	47.2	46.0	44.4	42.7	41.3
57	49.8	48.1	46.9	45.2	43.5	42.0
58	50.7	48.9	47.7	46.0	44.3	42.7
59	51.5	49.8	48.5	46.8	45.0	43.5
60	52.4	50.6	49.3	47.6	45.8	44.2
61	53.3	51.4	50.2	48.4	46.5	44.9
62	54.2	52.3	51.0	49.2	47.3	45.7
63	55.0	53.1	51.8	50.0	48.1	46.4
64	55.9	54.0	52.6	50.8	48.8	47.2
65	56.8	54.8	53.4	51.6	49.6	47.9
66	57.7	55.7	54.3	52.4	50.4	48.6
67	58.5	56.5	55.1	53.2	51.1	49.4

55862°—27——24

Table 86.—Minimum Depreciated Ground-Line Circumference of Wood Poles—Continued

Ground-line circumference when installed (inches)	Minimum allowable depreciated ground-line circumference for ratio of fiber stress when installed to fiber stress when depreciated of—					
	2/3	3/5	5/9	1/2	4/9	2/5
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
68	59.4	57.4	55.9	54.0	51.9	50.1
69	60.3	58.2	56.7	54.8	52.6	50.8
70	61.2	59.0	57.5	55.6	53.4	51.6
71	62.0	59.9	58.4	56.4	54.2	52.3
72	62.9	60.7	59.2	57.1	54.9	53.0
73	63.8	61.6	60.0	57.9	55.7	53.8
74	64.6	62.4	60.8	58.7	56.5	54.5
75	65.5	63.2	61.7	59.5	57.2	55.3

Table 87.—Allowable Depreciation of Wood Poles Under Vertical and Transverse Loading for Various Situations

[This table locates the situations to which the columns of Tables 86 and 88 apply]

	Ratio of maximum fiber stress when installed to maximum fiber stress when depreciated for—	
	Treated poles	Untreated poles
At crossings:		
In lines of one grade of construction throughout—		
Grade A	2/3	2/3
Grade B	2/3	2/3
Grade C	1/2	1/2
In isolated sections of higher grade of construction in lines of a lower grade of construction—		
Grade A	2/3	1/2
Grade B	2/3	4/9
Grade C	1/2	2/5
Elsewhere than at crossings:		
Grade A	2/3	5/9
Grade B	3/5	1/2
Grade C	2/3	1/2

Table 88.—Maximum Radial Depreciation of Wood Poles

Ground-line circumference when installed (inches)	Maximum allowable radial depreciation for ratio of fiber stress when installed to fiber stress when depreciated of—					
	2/3	3/5	5/9	1/2	4/9	2/5
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
24	0.48	0.60	0.68	0.79	0.90	1.01
25	.50	.62	.71	.82	.94	1.05
26	.52	.66	.72	.85	.98	1.09
27	.54	.67	.76	.89	1.02	1.13
28	.56	.70	.79	.92	1.06	1.17
29	.58	.72	.82	.95	1.09	1.21
30	.60	.75	.85	.99	1.13	1.26
31	.62	.77	.88	1.02	1.17	1.30
32	.64	.80	.91	1.05	1.21	1.34
33	.66	.82	.93	1.08	1.24	1.38
34	.68	.85	.96	1.12	1.28	1.42
35	.70	.87	.99	1.15	1.32	1.47
36	.72	.90	1.02	1.18	1.36	1.51
37	.75	.92	1.05	1.22	1.40	1.55
38	.76	.95	1.07	1.25	1.43	1.59
39	.78	.97	1.10	1.28	1.47	1.63
40	.80	1.00	1.13	1.31	1.51	1.68
41	.82	1.02	1.16	1.35	1.55	1.72
42	.85	1.05	1.19	1.38	1.58	1.76
43	.86	1.07	1.22	1.41	1.62	1.80
44	.88	1.10	1.25	1.44	1.66	1.84
45	.90	1.12	1.27	1.48	1.70	1.88
46	.93	1.15	1.30	1.51	1.74	1.93
47	.95	1.17	1.33	1.54	1.77	1.97
48	.97	1.20	1.36	1.58	1.81	2.01
49	.99	1.22	1.39	1.61	1.85	2.05
50	1.01	1.25	1.42	1.64	1.89	2.09
51	1.03	1.27	1.44	1.67	1.92	2.14
52	1.05	1.30	1.47	1.71	1.96	2.18
53	1.07	1.32	1.50	1.74	2.00	2.22
54	1.09	1.35	1.53	1.77	2.03	2.26
55	1.11	1.37	1.56	1.81	2.07	2.30
56	1.13	1.40	1.59	1.84	2.11	2.35
57	1.15	1.42	1.61	1.87	2.15	2.39
58	1.17	1.45	1.64	1.90	2.19	2.43
59	1.19	1.47	1.67	1.94	2.23	2.47
60	1.21	1.50	1.70	1.96	2.26	2.51
61	1.23	1.52	1.73	2.00	2.30	2.55
62	1.25	1.55	1.76	2.03	2.34	2.60
63	1.28	1.57	1.78	2.07	2.37	2.64

Table 88.—Maximum Radial Depreciation of Wood Poles—Continued

Ground-line circumference when installed (inches)	Maximum allowable radial depreciation for ratio of fiber stress when installed to fiber stress when depreciated of—					
	2/3	3/5	5/9	1/2	4/9	2/5
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
64	1.29	1.60	1.81	2.10	2.41	2.68
65	1.31	1.62	1.84	2.14	2.45	2.72
66	1.33	1.65	1.87	2.17	2.49	2.76
67	1.35	1.67	1.90	2.20	2.53	2.81
68	1.37	1.70	1.93	2.23	2.56	2.85
69	1.39	1.72	1.95	2.26	2.60	2.89
70	1.41	1.74	1.98	2.30	2.64	2.93
71	1.43	1.77	2.01	2.33	2.68	2.97
72	1.45	1.79	2.04	2.36	2.71	3.02
73	1.47	1.82	2.07	2.40	2.75	3.06
74	1.49	1.84	2.09	2.43	2.79	3.10
75	1.51	1.87	2.12	2.46	2.83	3.14

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

Table 89 gives the allowable number of No. 4 covered, solid, copper wires to be carried by a 35-foot pole of any wood having an ultimate fiber stress of 5,000 pounds per square inch. This number varies with the grade of construction and with the loading district. In this table it is assumed (1) that poles are set 6 feet in the ground; (2) that the cross arms are 2 feet apart; (3) that 6-pin cross arms are used up to 30 wires, and 8-pin arms for 31 or more wires; (4) that the placing of wires is begun at the top arm (wires 6 inches below the top of poles) and continues to lower cross arms after all wire positions are filled; (5) that the clearance of wires above ground is never less than 18 feet; (6) that the taper of poles amounts to 2 inches of circumference per 5 feet of length. Strengths are computed at the ground line. The values given apply to untreated poles in situations of conflict or joint use, or to poles either treated or untreated at crossings in a line of uniform construction. The values also hold for treated poles used at crossings where the construction differs from the remainder of the line.

Tables 90 and 91 are based upon the assumption (1) that the guys carry their loads with a factor of safety of 2; (2) that they are installed with a lead of 1 to 3; (3) that they are attached at the center of the load, thus making it unnecessary to take into account the height of the pole. The wind pressure on the pole itself has not been taken into account in these tables. This addition to the load is equivalent to that due to one or more wires, depending upon the size and height of the pole and length of span and deduction should be made in each case.

Table 89.—Allowable Number of No. 4 Solid Copper T. B. W. P. Wires to be Carried by Untreated 35-Foot Poles of Woods Classed as of 5,000 Pounds per Square Inch Ultimate Fiber Stress (Pine, Chestnut, Western Cedar, Cypress, etc.)

[For grades A, B, and C (except at crossings in isolated sections of higher grade) in heavy, medium, and light loading districts]

Grade and loading	Maximum stress in pole	Span	Allowable number of wires for ground-line circumference of—								
			32 in.	34 in.	36 in.	38 in.	40 in.	42 in.	44 in.	46 in.	48 in.
	*Lbs./in.*²	*Feet*									
A. H	1,670	100	[a] 4	5	6	8	9	11	14	16	18
		125	[a] 3	4	5	6	7	9	10	12	14
		150	[a] 3	3	4	5	6	7	9	10	11
		200	[a] 2	2	3	4	4	5	6	7	8
B. H	2,500	100	7	9	11	13	16	18	22	26	31
		125	6	7	8	10	12	14	17	20	23
		150	5	6	7	8	10	12	14	16	19
		200	3	4	5	6	7	9	10	12	14
C. H	3,750	100	11	14	17	21	26	30	35	[b] 40	[b] 40
		125	9	11	13	16	20	23	28	32	37
		150	7	9	11	13	16	19	22	27	29
		200	5	7	8	10	11	14	16	19	23
A. M	1,670	100	[a] 7	9	11	14	16	19	23	27	30
		125	[a] 5	7	9	10	12	15	17	20	24
		150	[a] 4	5	7	8	10	12	14	16	19
		200	[a] 3	4	5	6	7	9	10	12	14
B. M	2,500	100	12	14	18	22	26	30	36	[b] 40	[b] 40
		125	9	11	14	17	20	24	30	32	38
		150	7	9	11	14	16	19	23	27	30
		200	5	7	8	10	12	14	16	19	23
C. M	3,750	100	19	24	30	34	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40
		125	15	18	23	28	32	38	[b] 40	[b] 40	[b] 40
		150	12	15	18	22	27	31	37	[b] 40	[b] 40
		200	9	11	13	16	19	23	27	30	36
A. L	1,670	100	11	14	17	21	26	30	36	[b] 40	[b] 40
		125	9	11	13	17	20	24	29	32	38
		150	7	9	11	14	16	19	23	27	30
		200	5	8	8	10	12	14	16	19	22
B. L	2,500	100	19	24	30	34	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40
		125	15	18	23	28	32	39	[b] 40	[b] 40	[b] 40
		150	12	15	18	22	27	31	37	[b] 40	[b] 40
		200	9	11	13	16	19	23	27	31	36
C. L	3,750	100	30	38	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40
		125	25	30	36	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40
		150	20	25	30	36	[b] 40	[b] 40	[b] 40	[b] 40	[b] 40
		200	14	18	21	26	30	37	[b] 40	[b] 40	[b] 40

[a] For grade A in heavy and medium loading districts, 35-foot poles can not be used with so small a ground-line circumference, since pole top would be less than 7 inches. (See rule 261, A, 4, (*g*).)

[b] These numbers of wires will fill all available pole space when carried on 8-pin cross arms, but will not use up the available strength of the pole.

Table 90.—Allowable Number of No. 4 Solid Copper T. B. W. P. Wires to be Carried on Poles Supported by Side Guys of Various Strengths under Various Grades of Construction (A, B, or C) and Loadings (Heavy, Medium, Light)

Grade and loading	Span	Number of wires to be carried by poles supported by the following numbers and strengths of guys						
		One 4,000-pound	One 6,000-pound	One 10,000-pound	One 16,000-pound	Two 10,000-pound	One 10,000-pound, one 16,000-pound	Two 16,000-pound
	Feet							
A. H. and B. H.	75	9	13	22	36	45	59	73
	100	6	10	17	27	34	44	55
	125	5	8	13	22	27	35	44
	150	4	6	11	18	22	29	36
	200	3	5	8	13	17	22	27
C. H.	75	13	20	34	55	68	89	110
	100	10	15	25	41	51	67	82
	125	8	12	20	33	41	53	66
	150	6	10	17	27	34	44	55
	200	5	7	12	20	25	33	41
A. M. and B. M.	75	14	21	35	57	71	93	115
	100	10	16	26	43	53	70	86
	125	8	12	21	34	43	56	68
	150	7	10	18	28	35	46	57
	200	5	8	13	21	26	35	43
C. M.	75	21	32	53	86	107	140	172
	100	16	24	40	64	80	105	129
	125	12	19	32	51	64	84	103
	150	10	16	27	43	53	70	86
	200	8	12	20	32	40	52	64
A. L and B. L	75	22	33	55	88	111	144	177
	100	16	25	41	66	83	108	133
	125	13	20	33	53	66	86	106
	150	11	16	27	44	55	72	88
	200	8	12	20	33	41	54	66
C. L	75	33	49	83	133	166	216	266
	100	25	37	62	99	124	162	199
	125	20	30	49	79	99	129	159
	150	16	25	41	66	83	108	133
	200	12	18	31	49	62	82	99

Table 91.—Allowable Number of No. 8 B. W. G. Bare Iron Wires to be Carried on Poles Supported by Side Guys of Various Strengths under Various Grades of Construction (D or E) and Loading (Heavy, Medium, or Light)

Grade and loading	Span	One 4,000-pound	One 6,000-pound	One 10,000-pound	One 16,000-pound	Two 10,000-pound	One 10,000-pound, one 16,000-pound	Two 16,000-pound
D. H	75	10	16	27	43	54	70	86
	100	8	12	20	32	40	53	65
	125	6	9	17	26	32	42	52
	150	5	8	13	21	29	35	43
E. H	75	16	24	40	65	81		
	100	12	18	30	48	61	79	97
	125	9	14	24	39	48	63	78
	150	8	12	20	32	40	53	65
D. M	75	19	28	47	76	95		
	100	14	21	35	57	71	92	
	125	11	17	28	45	57	74	91
	150	9	14	23	38	47	61	76
E. M	75	28	42	71				
	100	21	32	53	85			
	125	17	25	42	68	85		
	150	14	21	35	57	71	92	
D. L	75	51	76					
	100	38	57	96				
	125	30	46	76				
	150	25	38	63				
E. L	75	76						
	100	57	86					
	125	46	69					
	150	38	57	95				

Note.—The blank spaces in the above tables indicate that more than 100 wires can be carried by the size and number of guys in question under the indicated conditions of hazard, loading, and span length without exceeding one-half of the ultimate strength of the guys. Where the number of wires carried by a pole exceeds 80 it is good practice to install some of them in cable.

Depth of Setting of Poles.

The values given in Table 92 are those recommended as the depth to which poles should be set under ordinary straight-line conditions in firm soil or rock. On corners or angles, or heavy dead-ends, these values should be increased by at least 6 inches. (See rule 262, B.)

Table 92.—Recommended Depth of Setting of Poles—Rule 262, B

Length of pole in feet	Setting in soil	Setting in rock
	Feet	*Feet*
20	5.0	3.0
25	5.0	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.0	5.0
60	7.5	5.0
65	8.0	6.0
70	8.0	6.0
75	8.5	6.0
80	9.0	6.5

Appendix G.—DEFINITION OF AMERICAN SOCIETY FOR TESTING MATERIALS OF DENSE SOUTHERN YELLOW PINE

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

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

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

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

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

PART 3. RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRIC UTILIZATION EQUIPMENT

CONTENTS

SEC. 30. SCOPE OF RULES AND GENERAL REQUIREMENTS

300. Scope of the Rules.

(a) **Voltage limits and occupancies.**—The following rules apply to electric utilization equipment between 25 and 750 volts, where accessible to other than qualified electrical operators, as in mills, factories, mercantile establishments, hotels, theaters, and other public buildings, cars and other vehicles, dwellings, and similar places. Communication equipment connected to communication lines (see definition) is exempted, except from rules under section 39.

(b) **Equipment of more than 750 volts.**—Equipment and conductors of more than 750 volts, where accessible to other than qualified electrical operators, shall (in addition to complying with the rules of part 3 for conductors of more than 300 volts) comply also with the rules for electrical supply stations, part 1, where such rules require more than the rules of part 3. Current-carrying parts shall be either incased in permanently grounded metal cases or conduits, or otherwise suitably guarded to prevent access (or too close approach) to such current-carrying parts by any but qualified persons.

(c) **Utilization equipment regarded as supply equipment.**—Electric utilization equipment, however, as well as generating equipment, if inclosed in a separate room which is inaccessible to unqualified persons, and if when in service under the control of a qualified person, may be installed in conformity with the rules applying to electrical supply stations (part 1) and in that case does not come under these rules.

301. Application of the Rules.

(a) **Waiving of rules.**—The rules are intended to apply to all installations except as modified or waived by the proper administrative authority or its authorized agents. They are intended to be so modified or waived in particular cases wherever any rules are shown for any reason to be impracticable, such as by involving expense not justified by the protection secured, provided equivalent or safer construction is secured in other ways.

Distinction is made between the requirements for installations which are accessible only to qualified persons and the requirements for installations accessible to other than qualified persons, as to the relative practicability of adhering closely to the literal requirements of the standard.

(b) **Intent of rules.**—The intent of the rules, which constitute a minimum standard, will be realized (1) by applying the rules in full to all new installations, reconstructions, and extensions; (2) by bringing existing installations into conformity with these rules as far as may be directed by the administrative authority and within the time determined by the administrative authority.

(c) **Temporary or emergency installations.**—It will sometimes be necessary to modify or waive certain of the rules in case of temporary or emergency installations or installations which are shortly to be discarded or reconstructed.

302. General Requirements.

(a) **Approved materials.**—Materials or devices which have been subjected to examination by some properly qualified body and found to comply with the general requirements of this code, the National Electrical Code, and other nonconflicting accepted standards which apply for any given purpose should be used; otherwise the approval of the administrative authority should be obtained in advance.

NOTE.—In order to avoid the necessity for repetition of such examinations by different examiners, frequently with inadequate facilities for such work, and to avoid the confusion which would result from conflicting reports as to the suitability of devices examined for a given purpose, it is necessary that such examinations should be made under standard conditions and the record made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determinations, through field inspections, and whose findings are subject to appeal to the Bureau of Standards.

(b) **Future inspections.**—Electric utilization equipment shall be installed and maintained in conformity with these safety rules. Persons in charge of equipment shall have periodic inspections of equipment and wiring made, and similar inspections shall be made by the supervising authority.

303. Reference to Other Codes.

Reference is made to the requirements in the current editions of the following codes:

National Electrical Code. A. E. S. C.................. C 1
Code of Lighting Factories, Mills, and Other Work Places. A. E. S. C.................................... A 11
National Safety Code for the Protection of the Heads and Eyes of Industrial Workers. A. E. S. C........ X 2
A Safety Code for Elevators, Dumbwaiters, and Escalators. A. E. S. C.............................. A 15

NOTE.—Copies of these codes can be obtained from the American Engineering Standards Committee, 29 West Thirty-ninth Street, New York, N. Y.

304. Grounding.

(a) **Grounding method.**—Where grounding is required, all grounding of circuits, lightning arresters, equipment, or wire raceways, which is intended to be a permanent and effective protective measure, shall be made in accordance with the methods specified in section 9.

(b) Circuits required to be grounded.—All circuits included in rule 300 (*a*) shall be permanently grounded in accordance with the rules of section 9, except that the following are not required to be grounded:

Exceptions.—(1) Circuits on two-wire direct-current systems.

(2) Circuits entirely unexposed to leakage or induction from higher-voltage circuits, either through overhead construction or through transformers or other devices. It is recommended, however, that all three-wire (not delta three-phase) circuits, even if unexposed, have their neutrals grounded; and that multiphase circuits, even if unexposed, where partly used for lighting, be so arranged and grounded that the lighting circuits, have the lowest practicable voltage to ground.

(3) Circuits of more than 150 volts to ground.

(4) Electric furnace circuits. (See rule 351.)

(c) Grounding noncurrent-carrying metal parts.—Under the conditions named below, fixed electric utilization equipment shall have the exposed noncurrent-carrying metal parts, such as frames of motors, cranes, cars, and switchboards, cases of transformers and switches, and casings of wiring and conductors permanently grounded. (See section 9 for method, and rule 371 for portable devices.)

Exception.—Parts of machines, such as name plates, screws in wood, and similar small parts, and metal covers of fuses and switch bases which are thoroughly and effectively insulated, and which are not liable to become alive except under very unusual circumstances, are not considered as coming under the rule and may be left ungrounded.

The following conditions shall be considered as requiring permanent grounding of noncurrent-carrying parts:

(1) All equipment operated at more than 150 volts to ground, regardless of location.

Exceptions.—No ground connection need be made to exposed metal frames of switchboards, motors, or lighting fixtures connected to direct-current trolley or third-rail circuits, or where accessible to qualified persons only, provided that such frames are effectively insulated from ground, and provided that the metal frames in question are so located with reference to insulating mats, floors, or platforms that persons can not readily touch the metal frames in question without standing on such mats, floors, or platforms.

No ground connection need be made to service-entrance conduits or to lengths not exceeding 25 feet of armored cable, metal raceways, or of conduit (or pipe of equivalent strength having each wire within protected with an extra covering of nonconducting flexible tubing) used for the protection of wires if they are insulated from piping and other grounded surfaces in the building and are out of reach from grounded surfaces. (See also rules 329 (*k*) and 344 for further exception.)

(2) All cases where exposed grounded surfaces, such as metal frames of other machines, plumbing fixtures, conducting floors or walls, exist within the reach of persons when touching the metal parts under consideration. (Usually grounded surfaces within 5 feet horizontally of the parts considered and within 8 feet vertically of the floor are considered within reach.)

(3) All locations where explosives, inflammable gas, or inflammable flyings normally exist in dangerous quantities, regardless of voltage.

305. Working Spaces about Electric Equipment.

(a) **Adequate space.**—Suitable working space shall be provided and maintained about all electric utilization equipment.

(b) **Dimensions.**—The horizontal dimension of the working space in front of live parts shall be not less than:

(1) For parts on one side of more than 150 volts to ground and no live or grounded parts on the other side of the working space, 2.5 feet.

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

(3) For parts on one side of less than 150 volts to ground and no live or grounded parts on the other, 1.5 feet.

(4) For parts on one side of less than 150 volts to ground and live or grounded parts on the other, 2.5 feet.

(c) **Clear spaces.**—Working spaces adjacent to exposed live parts shall not be used as passageways.

(d) **Elevation of equipment.**—The elevation of the equipment at least 8 feet above ordinarily accessible working platforms usually affords protection at least equivalent to that provided by the horizontal clearances of (*b*) and may be used in lieu thereof.

306. Guarding or Isolating Live Parts.

(a) **Inclosure or elevation.**—All bare, ungrounded live parts of electric utilization equipment, such as bus bars, conductors, and terminals, operating at more than 150 volts to ground, shall be protected by one of the following means:

(1) Inclosure, which gives access to live parts only through opening a door or cover.

(2) Guarding, as by railing, screen, or barriers which remove the liability of contact or approach.

(3) Isolation, by placing at least 8 feet above the floor line, or by removing beyond ready accessibility.

NOTE.—Inclosures may consist of suitable casings or suitable insulating coverings. The continuous insulating covering of conductors should be depended upon only when the circuit is grounded in accordance with section 9 or is less than 300 volts to ground and entirely unexposed to leakage or induction from higher-voltage circuits, and where, in addition, it is impracticable to install more suitable guards. It should be depended upon then only when the covering is not exposed to liability of mechanical injury and is very substantial, thoroughly dry, and contains no noninsulating flame-proofing compound or oil-soaked rubber. It is recommended that in addition to the protection afforded by such coverings the insulating mats or platforms called for in paragraph (*b*) be used.

Where covers, casings, or barriers must at any time be removed from the current-carrying parts which they guard while these parts are alive, the covers, casings, or barriers, should be of insulating material or so arranged that they can not readily be brought in contact with the live parts.

(b) Exception where mats and platforms are used.—Where current-carrying parts of more than 150 volts to ground must necessarily be exposed (unguarded) within 8 feet from the floor, all surrounding conducting floors and other conducting surfaces within reach shall be covered with suitable insulating platforms, mats, or other insulating devices.

NOTE.—Mats may be of wood, held together by wood pins, or of cork matting, linoleum, or rubber. The material and construction should be suitable for the voltage concerned and for the prevailing conditions. If subject to moisture or to accumulations of conducting dust, flyings, or chips, mats should present surfaces minimizing the hazards from these sources.

307. Hazardous Locations.

(a) When explosives and inflammables exist.—In locations where explosives, inflammable gas, or inflammable flyings normally exist in dangerous quantities, all parts at which high temperature, sparking, or arcing is liable to occur shall be inclosed by one of the following methods:

(1) By installing in a separate room or compartment, free from explosive material.

(2) By surrounding with an inclosure of nonabsorptive, noncombustible material capable of withstanding without injury and without transmitting flame to the outside any explosion that may occur within.

(b) **In damp places.**—External parts of lighting fixtures and all other electric equipment when within 8 feet of the floor in damp locations shall be constructed of noncombustible, nonabsorptive insulating materials or, if of metal, shall be grounded as required by 304 (*c*).

308. Protection by Disconnection.

Electric utilization devices which will require maintenance work upon them shall have approved means of disconnecting them from all ungrounded conductors of their supply circuits.

NOTE.—Every installation has a switch or switches controlling the power supply or subdividing it. These switches may be used as the required disconnecting means where readily accessible, but in many cases it is recommended that additional disconnecting means be provided for convenience and in order not to interfere with other apparatus.

(1) If the control apparatus opens all the main leads to the motor, and the pilot circuits are fused, a disconnector only is required for connected loads in excess of 50 horsepower. Smaller loads require a circuit switch.

(2) If the control apparatus does not open all of the main leads to the motor, a circuit switch shall be used.

NOTE.—By main leads to the motor is meant: *d. c. motors*—all armature circuits (not including shunt-field circuits); *a. c. motors*—all primary leads (not including the secondary leads of a slip-ring motor or the shunt field of a synchronous motor).

(3) The disconnecting means shall make all circuits of the controller and motor dead.

(4) A knife or snap switch regularly used for starting or stopping a motor is a controller and should be protected by disconnecting means.

NOTE.—A washing-machine motor controlled by a snap switch has a plug which serves the purpose of disconnecting means.

(5) If the disconnecting means is equipped for locking in the open position, it need not be in sight of the motor.

(6) When the starter is not designed for opening the motor circuit, a circuit switch should be provided in the branch circuit of each motor.

309. Identification of Equipment.

(a) **Safety by identification.**—All electric utilization equipment shall be suitably identified when added safety can be obtained thereby. (See also rules 312, 332, and 373.)

NOTE.—The identification may be by location, color, number, name plate, label design, or other means.

(b) **Voltage and use.**—The voltage and intended use shall be shown wherever it will reduce the hazard or decrease the liability of error in operation.

SEC. 31. CONDUCTORS

310. Electrical Protection.

(a) **Fuses and circuit-breakers.**—Each conductor (except neutral conductors, grounded conductors, grounding conductors, and conductors of circuits the opening of which may cause special hazard by the interruption of service or removal of protection) shall be protected against excessive current by a suitable fuse or other automatic circuit-breaking device or by the design of the system.

(b) **Grounded conductors.**—All conductors normally grounded for the protection of persons shall be arranged without fuses or other automatic circuit-breaking devices interrupting their continuity between the source of electrical supply and the point at which the grounding conductor is attached, unless the circuit-breaking device opens all conductors of the circuit with one operation.

Neutral conductors in three-wire systems shall be arranged without fuses or other automatic circuit-breaking devices interrupting their continuity, unless the circuit-breaking device opens all conductors of the circuit with one operation.

NOTE.—In two-wire branches from three-wire circuits the conductor connected to the neutral is not, for the purpose of this rule, considered a neutral conductor.

Where the utilization equipment is connected to electrical supply lines, the point of connection to the service leads is considered as the source of electrical supply.

(c) **Switches.**—Switches shall open all conductors of the circuit by one operation except as follows:

(1) The switch need not open a grounded conductor.

(2) Single-pole switches may be used in two-wire branch circuits; on grounded circuits they shall be placed in the ungrounded conductor.

(3) On three-wire systems with a grounded neutral conductor the service switch may open either outside wire independently of the other, provided the neutral can not be opened without opening both outside wires.

(4) Where service switch, fuses, and meter are combined in a single self-contained device having no exposed wiring or live parts and with connections inaccessible to unauthorized persons, the switch may be so arranged that it does not disconnect the potential coil of the meter.

311. Protective Covering.

(a) **Mechanical protection.**—Where exposed to mechanical injury, suitable casing, armor, or other means shall be employed to prevent injury or disturbance to conductors, their insulation, or supports.

(b) **Bare conductors.**—Bare conductors shall be used only for circuits of less than 300 volts to ground where accessible to qualified persons only, or in locations where insulated conductors are not feasible, such as contact conductors, bus bars, and battery connections. Such bare conductors shall be fixed at adequate separations by the use of suitable supports. Except at the point where a permanent ground connection is made, such conductors within buildings shall be kept insulated from the ground. Bare conductors shall not be used where inflammable gases or explosives are liable to be present. (See rules 307 and 314.)

312. Identification of Conductors and Terminals.

(a) **Conductors.**—The neutral conductor of three-wire circuits and one conductor of two-wire circuits shall be so arranged as to be readily identified. This may be done by maintaining a specified relative position on open wiring, or the conductors may be tagged or otherwise suitably marked where run in conduits. For rubber-covered wires (not including flexible cord or fixture wire) of size No. 8 (0.128 inch) and smaller the only allowable identification shall consist of a white or natural-gray covering. This conductor shall be run and maintained without change in polarity throughout the entire installation and connected at all fittings to marked terminals or to terminals which can be identified by their relative location to others, in order to preserve the continuity of the marking.

Exception.—Polarity may be changed between switch and device controlled, if necessary.

When the system to which the circuit is connected is a grounded system, the marked conductor shall be connected to the grounded conductor of this system.

On sockets and receptacles the marked conductor shall be connected to the screw shell.

(b) **Terminals.**—All devices provided with terminals for the attachment of wires and intended for connection to more than one side of the circuit shall, unless specifically excepted, have a pair of connecting terminals properly marked for identification, unless the electrical connection between the pair of terminals intended to be connected to the grounded conductor is clearly evident.

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

The terminals of utilization devices need not be marked to indicate the proper connection to the grounded conductor. If a terminal of a utilization device which includes a single-pole switch is marked, the switch shall not be in the identified side of the circuit.

The terminals of portable devices need not be marked for identification.

Devices such as single-pole and three-way switches, to the terminals of which only one side of the line is connected, need not have terminals marked for identification.

Rosettes, attachment-plug receptacles without screw shells, and attachment-plug caps need not have their terminals marked for identification. When terminals of polarized receptacles for attachment plugs and attachment-plug caps are marked for identification, the terminal intended for connection to the grounded wire shall be the marked terminal.

Three-wire attachment-plug receptacles and three-wire attachment caps in which one terminal may be used for the connection of a grounding conductor shall have such terminal identified in a manner differing from that specified below.

In the case of devices with Edison screw shells, except plug-fuse receptacles, the identified terminal shall be the one connected to the screw shell.

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

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

313. Guarding and Isolating Conductors.

Insulated conductors of more than 300 volts to ground, or open, bare, ungrounded conductors of all voltages, if less than 8 feet above the floor or working platform and accessible to unqualified persons, shall be guarded by approved screens, barriers, or inclosures.

314. Guarding in Damp or Hazardous Locations.

(a) Support of conductors in damp locations.—Conductors in damp locations or where exposed to corrosion, if not in waterproof conduit, or in waterproof metal sheaths in other suitable ducts, shall be effectively isolated and supported on insulators of a suitable type.

(b) Conduit for conductors in hazardous locations.—Conductors in locations where inflammable gas or flyings normally exist shall be in grounded metal conduit or metal-sheathed cable. All fittings and outlets of such conduit and cable shall be electrically and mechanically continuous with the conduit or metal sheath, and the conduit shall be sealed by the use of suitable potheads or equivalent devices to prevent entrance of gases.

315. Precautions Against Excessive Inductance and Eddy Currents.

Supply conductors of alternating-current or direct-current circuits should not be run in separate iron conduits or on opposite sides of I beams or other iron structures or be otherwise run so as to increase abnormally the self-inductance of the circuit.

NOTE.—Such construction, by introducing large self-inductance in direct-current circuits, causes fuses to blow explosively; in alternating-current circuits it causes heating due to eddy currents in the metal.

316. 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, and this covering shall be securely held in place.

317. Grounding or Isolating Service and Interior Conduits.

Where service conduit or sheathing is electrically continuous with interior conduit or sheathing, the grounding required for conduit (by rule 304 (*c*)) shall be made directly to the service conduit or sheathing and shall have conductance not less than that of No. 8 (0.128-inch) copper wire.

NOTE.—It is frequently advisable to insulate interior conduit or sheathing from service conduit or sheathing to prevent burn-outs of small interior conduit, armored cable sheaths, or metal molding by large currents which might flow from exterior conduit to interior conduit and water pipes.

SEC. 32. FUSES, CIRCUIT-BREAKERS, SWITCHES, AND CONTROLLERS

320. General Requirements for Switches.

(a) **Accessibility, marking, and installation.**—(1) All switches, fuses, automatic circuit-breakers, motor starters, and other control devices shall be readily and safely accessible and shall be installed in such a manner as to minimize the danger of accidental operation.

(2) The place of operation of starters and controllers for motors, heaters, and furnaces shall be within sight of the motor or equipment controlled, except where it is inaccessible to other than qualified and authorized persons.

NOTE.—This is to minimize the hazard of starting when persons are in dangerous positions, but exception is made to permit the remote control of fans, pumps, etc., when properly isolated.

(3) When controlling circuits to which motors are permanently connected or other circuits of capacities greater than 1,320 watts, switches shall be so located or marked as to indicate their function.

(4) Where practicable, switches shall be so installed that gravity can not close them; and such switches as may close by gravity shall be provided with a stop block or latch to prevent accidental closing.

(b) **Switches for special circuits.**—Switches controlling emergency lighting circuits, elevator circuits, circuits in theaters, hospital operating rooms, and other circuits the interruption of which might cause special hazard, shall be arranged so as to be accessible only to authorized persons.

(c) **Exit lights.**—Exit lights and all lamps normally kept lighted in halls, corridors, and any other part of theaters and assembly halls used by the audience, except the general auditorium lighting, must be fed independently of the stage lighting, and must be controlled only from the lobby or other convenient place in front of the house.

321. Hazardous Locations.

When necessary to install fuses, circuit-breakers, switches, or other control devices in locations where explosives, inflammable gas, or inflammable flyings exist, they shall be suitably protected. (See rule 307.)

322. Where Switches Are Required.

(a) **Service switches.**—Suitable switches, circuit-breakers, or equivalent devices shall be inserted in all feeder conductors connecting utilization installations to service connections from either overhead or underground lines. These switches shall be readily accessible and as close as practicable to the point where the service enters the building.

A fuse or automatic circuit-breaker shall be placed in each ungrounded service conductor, and unless access to fuses is under control of the electric service company they shall be disconnected by opening the service switch.

Unless mounted upon a switchboard or panel board accessible to qualified persons only, service switches, fuses, and circuit-breakers shall be inclosed. Switches shall be operable without opening the inclosure unless additional switches are provided for separate control of the individual circuits, such switches being inclosed and externally operable.

(b) **Circuit switches.**—Suitable switches, circuit-breakers, or equivalent devices shall be inserted in all circuit leads to lamps, motors, transformers, storage batteries, electric furnaces, and similar utilization equipment to make possible the independent disconnection of all such equipment from the source of supply.

NOTE.—On a branch circuit not exceeding 15 amperes or 150 volts, plug fuses are recognized as an equivalent device.

Exceptions.—(1) Parts or pieces of apparatus intended to operate as a unit, as a motor and its starting device, may be controlled by one switch.

(2) The switch need not open a grounded conductor. (See rule 310 (*b*) (*c*).)

(3) A group of incandescent lamps on the same branch circuit may be disconnected by one single-pole switch in the ungrounded conductor.

(4) One switch may serve to disconnect several motors and their starting devices from the source of supply, if it complies with rule 308.

NOTE.—The use of a disconnecting means for each motor or a group of motors is a question of judgment, depending upon the frequency of attention required by the motor and controller.

Single-pole switches shall not be placed in any neutral or grounded conductor. Three-way switches, or three-way and four-way switches used in combination, shall be classed as single-pole switches and shall be so wired that only one pole of the circuit will be carried to any switch.

(c) **Panel boards.**—Switches shall be so placed that each panel board may be independently disconnected from the source of supply, for all circuits exceeding 15 amperes or 150 volts.

Exception.—Such switches are not required if the panel boards are equipped with switches for disconnecting individual branch circuits or groups of branch circuits from their supply circuit.

(d) **Fuses.**—Switches shall be provided as necessary to make possible the disconnection of all fuses from the source of electrical supply before being handled, except as provided in 324 (*b*).

(e) **Switches or plugs on portables.**—Switches or plug connectors shall be installed to permit the disconnection of temporary wiring, or of portable conductors from permanent or fixed wiring.

323. Character of Switches and Disconnectors.

(a) **Interrupting capacity of switches.**—Switches used otherwise than as disconnectors shall have a capacity such as to insure safe interruption, at the working voltage, of the greatest current which they will be required to carry continuously, and shall be marked with the current and voltage for which they are rated.

(b) **Capacity of disconnectors and warning signs.**—Disconnectors shall be of suitable voltage and ampere rating for the circuit in which they are installed and shall be accessible only to properly qualified persons. They shall also be protected by signs warning against opening them while carrying current in excess of the safe opening limit.

NOTE.—Interlocking arrangements are desirable to prevent opening of such disconnectors under loads beyond their safe opening capacity and locking arrangements to prevent accidental opening.

(c) **Locking or blocking.**—Where dependence for maintaining an open circuit as a protection for persons against unexpected starting or energizing the circuit is put on certain switches or circuit-breakers, such switches or circuit-breakers shall be so arranged that they can be locked, blocked, or otherwise secured in the "Off" or "Open" position. (See rules 328 (*a*), (*b*), and 329 (*l*).)

Exception.—Small-capacity snap switches, if near machines and in plain sight from all parts of the machines controlled, are exempted. 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.

NOTE.—Locking is to be preferred to blocking, wherever parts of the machinery driven are remote from the point of control.

(d) **Good contact.**—Switches, controllers, and rheostats shall be so constructed as to make and maintain good contact.

Knife switches shall maintain such alignment under service conditions that they may be closed with a single unhesitating motion.

(e) **Inclosure of switches.**—Switches shall be of inclosed type unless inaccessible to other than qualified persons. (See rule 328.)

(f) **Manual operation for power-operated apparatus.**—Power-operated circuit-breakers and similar switching apparatus, excepting magnetic contactors, shall be provided with means for readily closing and opening them manually.

324. Disconnection of Fuses and Thermal Cut-outs Before Handling.

(a) **Automatic disconnection.**—Fuses in circuits of more than 150 volts to ground shall, where accessible to others than qualified electrical attendants, be so arranged that the fuses are necessarily disconnected from all sources of electrical energy before they can be touched. Where the circuit voltage is less than 150 volts to ground, this protection is recommended.

NOTE.—This may be accomplished by a construction in which the fuse and its exposed current-carrying connections are accessible only when disconnected from the circuit, either by opening the fuse inclosure or by other means.

Where fuses are in locked cabinets (or otherwise made accessible only to qualified persons) sufficient protection is usually secured for all voltages if switches are provided to disconnect the fuses from all sources of electrical energy.

When switches and fuses are inclosed in metal cabinets and live terminals are accessible, greater hazard exists than if they were not so inclosed, as the live terminals are adjacent to grounded metal.

(b) **Switch ahead of the fuse.**—Where fuses are not arranged so that they are necessarily disconnected from all sources of electrical energy before they can be touched, switches shall be so placed or arranged that opening them will disconnect the fuses from all sources of electrical energy, except service and meter switches, access to which is controlled by the electric service company.

If, in order to comply with the above, the supply wires must be connected to certain terminals, such terminals shall be marked "Line" and the other terminals shall be marked "Load," or with other appropriate designation.

(c) **Live load.**—Where a fused inclosed switch, accessible to unqualified persons, is connected between a source of supply and a live load of more than 150 volts to ground, as in the charging circuit of a storage battery, switches shall be used in which the fuses are so arranged that they will be disconnected before they become accessible unless a supplementary switch is provided for disconnection of the live load from the fuses.

(d) **Thermal cut-outs.**—Thermal cut-outs shall comply with the requirements for fuses in (*a*) and (*b*).

325. Arcing or Suddenly Moving Parts.

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

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

(c) **Marking.**—Oil switches and oil circuit-breakers shall be marked with the following data:

(1) Manufacturer's name and address.
(2) Manufacturer's type and designation number.
(3) Rated amperes.
(4) Rated volts.
(5) Frequency if other than 60 cycles.

Such marking shall be placed on the switch or circuit-breaker and not on removable parts that may be interchanged.

326. Grounding Noncurrent-carrying Metal Parts.

Exposed noncurrent-carrying metal parts of switch and fuse cases, levers, and other similar parts to which leakage may occur from live parts shall be permanently grounded according to the provisions of rule 304.

Exception.—Small parts, such as name plates, screws, and metal covers of fuses and switch bases, which are thoroughly and effectively insulated, and which are not liable to become alive except under very unusual circumstances, are not considered as coming under the rule and may be left ungrounded.

327. Guarding Live Parts.

(a) **Guard disks and handles.**—All manual switches, except switches less than 150 volts to ground and limited by fuses or automatic circuit-breakers to 60 amperes, shall have suitable casings or guards protecting the operator from danger of contact with current-carrying parts, or 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

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

(c) **Platforms and mats.**—Where switches or fuses of more than 150 volts to ground are not guarded during ordinary operation, suitable insulating floors, mats, or platforms shall be provided on which the operator must stand while handling the switches, fuses, or automatic circuit-breakers, and (unless operators invariably wear suitable insulating gloves while handling the switches) any conducting walls or machine frames within 3.5 feet shall be provided with suitable insulating guards.

NOTE.—The suitable guarding of live parts will obviate the necessity of such insulating floors and other devices, and where use of such devices is impracticable from the nature of the location or mechanical process carried on, guards should always be used.

(d) **Blades dead.**—Single-throw switches shall be so connected as to have no exposed blades alive when a switch is open.

328. Inclosed Air-break Switches (not Including Snap Switches).

(a) **Locks for switches.**—Inclosed switches shall be provided with means for locking or sealing the switch in the "Off" position.

(b) **Locks for disconnectors.**—Inclosed disconnecting switches shall have provisions for locking in both open and closed positions, where accessible to unqualified persons.

(c) **Marking.**—Inclosed switches shall be plainly marked to show the manufacturer's name or trade-mark, the rating of the switch in amperes and volts (a. c. or d. c.), the open and closed positions of the switch handle, and, when necessary for proper functioning, the terminals to be connected to "Line" and "Load." The marking of the manufacturer's name, the voltage, and the open and closed positions shall be on the outside of the case.

(d) **Operating handle.**—Inclosed switches shall be externally operable without opening the inclosure, and the operating handle shall be of substantial construction, readily accessible, and provided with positive stops limiting its motion.

(e) **Grounding.**—Inclosures and metal handles of switches shall be permanently grounded.

Note.—Where a handle consists of a metal rod using the wall of the case as a bearing, and a test at rated voltage shows that the two make electrical contact, the handle will not need a separate ground connection.

(f) **Unused openings plugged.**—All unused conduit and wiring openings in switch inclosures shall be effectively closed by metal plugs or plates.

329. Control Equipment.

(a) **Classes of inclosures.**—Inclosures are classified as follows:

Class I.—A solid inclosure without slot or other opening.

Class II.—A solid inclosure except for a slot for the operating handle or openings for ventilation, or both.

Class III.—Wire mesh, perforated screens, or grill work.

(b) **Material for inclosures.**—In the following it is assumed that steel (or gray iron for castings) will be the metal employed. Copper, bronze, and brass are sometimes used, in which case the requirements given for steel shall be complied with.

Cast metal for protective parts, whether of iron or other metal, shall be at least one-eighth inch thick at every point, and should be of greater thickness at tapped holes for conduit, at reinforcing ribs, and door edges.

The minimum thickness required for sheet-metal construction varies with the size of the device. For Classes I and II protective parts of sheet metal shall be of gauge not less than that given in Table 1.

Table 1.—Thickness of Inclosures

Maximum volume of inclosure in cubic feet	Maximum area of any surface in square inches	Maximum dimension in inches	Without supporting frame		With supporting frame or equivalent reinforcing	
			U. S. sheet steel gauge	Inch	U. S. sheet steel gauge	Inch
¾	-------------	12	20	0.037	24	0.025
1	-------------	18	18	.050	20	.037
	360	24	16	.062	18	.050
	1,200	48	14	.078	16	.062
	Over 1,200	------------	10	.141	16	.062

Wire screening used for inclosures must conform to the following:

Maximum opening in screen	Minimum wire size, steel wire gauge
½ inch	No. 16
More than ½ inch and not more than 2 inches	No. 12

Where the opening is more than one-half inch the inclosure shall not be less than 4 inches from any live part.

(c) **Clearances.**

(1) There shall be sufficient space within the inclosure to permit uninsulated parts of wire terminals to be separated so as to prevent their coming in contact with each other. Inclosures shall be such as to permit proper wire connections to be made with adequate spacing of the terminals and ends of conductors from adjacent points of the inclosures.

(2) Exposed nonarcing current-carrying parts within the inclosures shall have an air space between them and the uninsulated part of the inclosure of at least one-half inch for 750 volts or less. Inclosures of sizes, material, or form not securing adequate rigidity shall have greater spacing.

Table 2.—Air Spaces in Controllers

Horsepower rating	Distance from contacts in direction of blow-out		Vertical distance above contacts without blow-out				Horizontal distance from contacts and distance below contacts	
	D. c. and a. c.		D. c.		A. c.		D. c. and a. c.	
	300 volts	750 volts	300 volts	750 volts	300 volts	750 volts	300 volts	750 volts
	Inches	*Inches*	*Inches*		*Inches*	*Inches*	*Inches*	*Inches*
5	1¾	3	4	[1]	1¾	3	¾	1½
10	2	4	5	[1]	2	4	¾	1½
50	3	5	6	[1]	3	5	1	2
100	4	[1]	[1]	[1]	4	[1]	2	3
Above 100	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]

[1] Barrier.

Note.—All distances to be measured from contact tips or arc horns.

(3) Where the walls of the inclosure are not protected by a barrier or a lining of noncombustible insulating material, the arc-rupturing parts of the controller shall have the air spaces given in Table 2 between them and the walls of the inclosure. Where "barrier" appears in table, one shall be provided.

Exception.—This table will not apply when a test on any specific device demonstrates that a smaller space or omission of the barrier is safe for that particular device.

(d) **Securing covers, etc.**—All inclosures and parts of inclosures, such as doors, covers, tanks, etc., shall be provided with means for firmly securing them in place. Among the available means are locks, interlocks, screws, and seals.

(e) **Inclosures for floor-mounted controllers.**—For voltages not in excess of 750 volts:

(1) Where the surrounding inclosure is 6 feet or more in height and exposed live parts are not less than 6 inches below the upper edge, no covering is required across the top of the inclosure.

Exception.—Where cranes or other movable apparatus or operations of a special character may introduce possible hazards from above, overhead inclosures may be required.

(2) Where the surrounding inclosure is within 6 inches of the floor and exposed live parts are not less than 6 inches above the lower edge, no covering will be required for the bottom.

(f) **Marking.**—All industrial control equipment shall be marked to give the following information:

(1) Controllers shall be marked to indicate the duty for which they are designed, such as starting, intermittent, continuous, etc.

(2) Controllers shall be marked to indicate the power, volts, and whether direct current or alternating current. Alternating-current controllers shall be marked to indicate the cycles and number of phases.

(3) Field rheostats shall be marked to indicate the total ohms, volts, ampere capacity of first step, and ampere capacity of last step.

(4) The position of the controller handle shall be marked where necessary as a guide for proper operation.

(g) **Wiring diagram.**—A detail wiring diagram shall be supplied with every control equipment, and where practicable this diagram shall be permanently attached to the controller or mounting. All terminals on the control equipment shall be plainly marked to correspond with the markings on the diagram.

NOTE.—It is very desirable that instruction books, tags, or cards accompany each controller installation showing in detail how to properly repair and adjust various parts of the equipment.

(h) **Overload protection.**—All control equipment shall include an automatic device which will interrupt the electric power when the current exceeds a predetermined value.

Such overload protection need not be a part of the controller but may be a separate unit. When a part of the controller, such overload protection shall conform to all applicable rules for the control equipment.

(i) **Under or low voltage protection.**—Where the restarting of the motor on restoration of voltage may result in injury to any person or persons, under or low voltage protection shall be furnished.

NOTE.—When the motor and driven machinery are isolated and accessible to qualified persons only, the provision of a disconnecting switch eliminates the hazard.

(j) **Installation of controllers.**—When in excess of 150 volts to ground and located so that other than qualified persons have access to the controller, self-contained manual controllers and the manually operated parts of any controller shall be inclosed and operable from the outside of the inclosing case. When manual controllers are not inclosed, but are so located that only qualified persons have access to the controller, they shall meet the following requirements:

(1) The operating handle shall be so arranged that it can readily be grasped without danger of contact with live parts.

(2) The arc-rupturing parts shall be so located or shielded as to afford protection from an arc or flash.

(k) **Remote-control apparatus.**—Remote-control apparatus in excess of 150 volts to ground shall be so inclosed, guarded, or isolated that qualified persons only have access to it. Remote-control apparatus when not inclosed and when so located that qualified persons only have access to it shall have the terminals, contacts, and such parts as require inspection and renewal so arranged and spaced that they are accessible.

When the voltage to ground exceeds 300 volts an insulating mat or platform shall be provided on which the qualified person must stand while inspecting the controller, and any conducting surfaces within 3½ feet shall be provided with insulating guards. The exposed noncurrent-carrying parts of the controller, such as the frame, shall not be grounded.

(1) **Lock for control in "Off" position.**—Where the nature of the installation is such that the unauthorized operation of a controller may cause an accident to persons engaged in repair or adjustment of the motor or machinery driven by it, provision shall be made for locking the operating handle or disconnecting means in the "Off" position or the operating handle shall be removable.

SEC. 33. SWITCHBOARDS AND PANEL BOARDS

330. Accessibility and Convenient Attendance.

(a) **Control arrangement.**—Switchboards and panel boards shall have all switches so arranged that the means of control are readily accessible to the operator.

(b) **Location of instruments.**—Instruments, relays, or other devices requiring reading or adjusting shall be so placed that work can be readily performed from the working space provided.

331. Location and Illumination.

Switchboards shall be so placed that the persons necessarily near the board will not be endangered by machinery or equipment located near the board. Means for adequate illumination shall be provided.

Switchboards shall be made of noncombustible material and shall be kept free from moisture.

Switchboards shall be so installed and supported that they will withstand the stresses imposed by the operation of the apparatus mounted thereon, braces or other framework being installed if necessary.

332. Arrangement and Identification.

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

It is recommended that a diagram of switchboard or panel-board connections and devices be kept posted in some convenient place near such equipment.

333. Spacings, Barriers, and Covers.

(a) **Separation of bare parts.**—Bare parts of different potential on the front of switchboards, if accessible to unqualified persons, shall be so located or protected that they will not be readily short-circuited by tools or other objects.

(b) **Portable covers or shields.**—Switchboards shall have current-carrying parts which are ordinarily isolated or guarded, but which may occasionally require adjustment or repair while alive, so arranged that suitable portable covers or shields can be effectively placed to protect workmen from contact with any neighboring live parts.

334. Grounding Frames.

Switchboard frames and metal cabinets shall be permanently grounded, with the exceptions noted in rule 304.

335. Guarding Current-carrying Parts.

(a) **Inclosure of parts at more than 150 volts to ground.**—No switchboard or panel board operating at more than 150 volts to ground shall have current-carrying parts exposed within 8 feet of the floor, unless accessible only to qualified operators. Parts of 100 to 150 volts to ground should not be accessible to unqualified persons. Locked cabinets or other inclosures may be provided where necessary to prevent such exposure. If the current-carrying parts are at any time exposed while alive, conducting floors about such boards shall be provided with a suitable insulating platform or mat so placed that no live parts can be inadvertently touched except while standing on the platform or mat. (See rules 306 and 327.)

(b) **Inclosure of low-voltage parts.**—All switchboards and panel boards should be so arranged that current-carrying parts less than 150 volts to ground and less than 5 feet above the floor are inclosed in cabinets or screens.

NOTE.—This is an effective precaution against accidental short-circuit or contact by persons in the vicinity.

(c) **Plug-type boards.**—Plug-type switchboards on constant-current systems, or if of more than 150 volts to ground, shall have no current-carrying parts exposed on face of boards, and plug connectors shall have all current-carrying parts guarded as long as they are alive.

(d) **Dead-front boards.**—Switchboards having no current-carrying parts exposed on the face (working space) shall be used in theaters and similar places where rapid handling is necessary and the attention must be given to signals or to other processes.

(e) **Theater boards.**—Theater switchboards at any voltage, if having current-carrying parts exposed on back to passers-by, shall be elevated or guarded by suitable railings to prevent contact with live parts.

336. Fuses on Switchboards.

(a) **Disconnection of fuses.**—Fuses on switchboards shall be arranged in one of the following ways:

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

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

(3) So that they can be conveniently handled by means of suitable insulating tools provided for the purpose.

When switchboards are accessible to unqualified persons the protection specified in (1) shall be provided if the voltage exceeds 150 and should be provided if the voltage is less than 150.

(b) **Location of fuses.**—Fuses shall be so located as to obviate the danger in removing or replacing them of short-circuiting other live parts. Open-link fuses shall not be installed on switchboards.

337. Panel Boards.

(a) **Arrangement of equipment.**

(1) *Location of fuses.*—Fuses shall be so located as to limit as far as practicable the danger of short-circuiting other live parts when removing or replacing them.

(2) *Connection of plug-fuse shells.*—The shells of plug-fuse receptacles in ungrounded conductors shall be connected to the load side of the circuit on all panel boards employing plug fuses without switches in main or branch circuits.

(b) **Material.**—Panel-board bases shall be made of nonabsorptive, noncombustible insulating material.

(c) **Marking.**—Panel boards shall be plainly marked to show the manufacturer's name or trade-mark and the rating in volts and amperes. The ampere rating shall be the maximum capacity of the busses.

(d) **Protection against moisture.**—Where panel boards are installed so as to be exposed to excessive moisture they shall be inclosed in weatherproof cabinets.

(e) **Hazardous locations.**—Panel boards shall not be installed where hazardous conditions exist due to the presence of inflammable gas or inflammable dust or flyings.

(f) **Residences.**—Panel boards in residences shall be so installed that the lowest live part exposed when the cabinet door is open to permit operation of switches shall not be less than 4 feet from the floor.

SEC. 34. MOTORS AND MOTOR-DRIVEN MACHINERY

340. Control Devices.

(a) **Speed limitation.**—Machines of the following types shall be provided with speed-limiting devices, unless their inherent characteristics or the load and the mechanical connection thereto are such as to safely limit the speed or unless the machine is always under the manual control of a qualified operator:

(1) Separately excited direct-current motors.

(2) Series motors.

(3) Motor generators and converters which can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

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

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

(c) **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.

(d) **Under or low voltage protection.**—Where the restarting of the motor on restoration of voltage may result in injury to any person or persons, under or low voltage protection shall be furnished. When the motor and driven machinery are isolated and accessible to qualified persons only, the provision of a disconnecting switch eliminates the hazard.

341. Hazardous Locations.

Motors in which sparking or arcing can occur during operation shall, when in locations where explosives or inflammable gas or inflammable flyings exist, be suitably protected as described in rules 307 and 304 (*c*).

342. Deteriorating Agencies.

(a) **Inclosures.**—Suitable guards or inclosures shall be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where installed directly under equipment or in other locations where dripping oil, excessive moisture, steam, vapors, chemicals, or similar injurious agencies exist.

(b) **Grounding frames.**—The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded. (See rule 304 (*c*).)

343. Guards for Live Parts.

(a) **Inclosure of live parts.**—Motors of more than 150 volts to ground, unless isolated by elevation at least 8 feet above the floor line, should be provided with permanent inclosures or other suitable guards so arranged as to prevent persons or conducting objects from inadvertently coming or being brought into contact with live parts or interfering with the operation of the motors.

(b) **Mats and platforms.**—Suitable insulating mats or platforms of substantial construction and providing good footing shall be so placed on floors and, if necessary, on frames of machines having exposed live parts of more than 150 volts to ground that the operator or other persons in the vicinity can not readily touch such parts unless standing on the mats, platforms, or insulating floors.

NOTE.—The suitable guarding of live parts by inclosures or barriers effective during attendance or necessary adjustments of live parts will obviate the necessity for insulating mats, and where such mats are impracticable from the nature of the location or processes carried on guards shall always be used.

Where connectors are used in motor leads, these should be provided with insulating covering equal to that on the conductors.

(c) **Steps and handrails.**—Where necessary, steps and handrails should be installed on or about large machines to afford safe access to live parts which must be examined or adjusted during operation.

344. Grounding Machine Frames.

Where two or more machines, either of which operates at more than 150 volts to ground, are mechanically coupled together, and the operator can touch the frames of more than one at a time, the frames of all such machines shall be permanently grounded as required by rule 304 (*c*), unless they are bonded together electrically and surrounded by insulating mats or platforms on which persons must stand in order to touch the machine frames. If operating at more than 300 volts to ground, their frames shall always be grounded as required by rule 304 (*c*), and frames shall also be grounded wherever, from the nature of the location or of processes carried on, the use or maintenance of insulating mats or platforms is impracticable.

345. Protecting Moving Parts.

Suitable guards or inclosures shall be arranged at each motor or motor-driven machine when necessary to prevent persons or objects from inadvertently coming in harmful contact with moving parts, including chains, belts, gears, and pulleys.

SEC. 35. ELECTRIC FURNACES, STORAGE BATTERIES, TRANSFORMERS, AND LIGHTNING ARRESTERS

350. Protection from Burns.

(a) **Inclosure of glowing parts.**—Electric furnaces and apparatus used for arc welding, where intensely glowing incandescent or arcing parts are exposed, shall be inclosed so that those parts will not be accessible or visible to unqualified persons.

(b) **Screens, hoods, goggles.**—Suitable protecting screens, hoods, goggles, gloves, and other devices shall be provided for the qualified persons who must work or come near such exposed parts. (See National Safety Code for the Protection of the Heads and Eyes of Industrial Workers, A. E. S. C., X 2, for mechanical and optical protection.)

351. Grounding of Furnace Frames.

The outside noncurrent-carrying metallic frames of furnaces shall be permanently grounded if they contain current-carrying parts connected to circuits of more than 150 volts to ground, or if the circuit within is not grounded and is exposed through transformer windings to a circuit of more than 150 volts to ground.

352. Guarding Live Parts.

Except at points where necessarily left exposed (as at spot-welder contacts), current-carrying parts of furnaces, welders, and control equipment of more than 150 volts to ground shall be suitably guarded with inclosures or barrier guards.

353. Storage Batteries.

The installation of nonportable storage batteries of more than 50-kilowatt-hour capacity at the 8-hour rate of discharge shall be in accordance with the requirements given in section 13 of the rules for stations. Where storage batteries (not included under sec. 13) are placed in rooms used also for other purposes, adequate guards or inclosures shall be provided when it is necessary to prevent the approach of unauthorized persons, and special means of ventilation when necessary to prevent the accumulation of inflammable gas. For all batteries whose operating voltage exceeds 150, construction shall comply with rules 133 and 306 (*b*).

354. Transformers.

The installation of transformers having either winding of more than 300 volts to ground shall comply with the rules of section 14 of the rules for stations, and if the operating voltage of any winding exceeds 750 the transformers shall be made inaccessible to unqualified persons.

355. Lightning Arresters.

The installation of lightning arresters shall comply with the rules of section 18 of the rules for stations, and if the operating voltage of the circuit exceeds 750 volts the arresters shall be inaccessible to unqualified persons.

Lightning arresters when installed for the protection of utilization equipment may be installed on supply lines or service leads either within or without the buildings or inclosures containing the equipment to be protected. They shall be installed in accordance with the rules of parts 1, 2, or 3, depending upon their location, whether in stations, on outdoor lines, or with utilization equipment

SEC. 36. LIGHTING FIXTURES AND SIGNS

360. Grounding.

The exposed noncurrent-carrying metal parts of all lighting fixtures and other similar fixed electrical devices shall be permanently grounded when used under the following circumstances (for exception, see rule 304 (*c*)):

(1) When in locations where explosives, inflammable gas, or inflammable flyings exist in dangerous quantities.

(2) When within touching distance or about 8 feet from metal, concrete, or permanently damp floors or stairways, including fire escapes, galleries, or bridges, as in machine shops, stables, laundries, etc.

(3) When readily accessible from the ground or floor and also within 5 feet from conducting surfaces, such as metal piping, metal radiators, stoves, furnaces, plumbing fixtures, damp walls, or similar conducting surfaces, as in kitchens, machine shops, print shops, etc.

On grounded systems the center contacts of sockets and receptacles shall be connected to the ungrounded side of the system, and the inner screw shell of the devices to the grounded side or neutral.

NOTE.—This is in order to reduce the liability of breakdown of the dielectric between the inner screw shell and the grounded outer brass shell, and also to reduce the liability of injury to persons in replacing lamps. This is especially important in wiring electric signs.

Exceptions.—(1) In lieu of grounding the external metal parts of lamp sockets, where suitable means for grounding are not readily available (as sometimes in the case with knob and tube wiring not near plumbing fixtures), sockets and lamp guards or similar devices of suitable insulating material may be used.

(2) Combination gas and electric fixtures may be left ungrounded if thoroughly insulated from their supports.

361. Receptacle for Convenience Outlet.

Sockets or receptacles not employed as lamp or fuse holders shall be so designed or installed that no current-carrying parts will be exposed.

362. Exposed Live Parts.

Electric fixtures, including lamp sockets and lamp bases, if within reach of grounded surfaces, shall be so designed and installed that no current-carrying parts will normally be exposed externally.

363. Signs.

(a) **Accessibility.**—Electric signs at an elevation greater than 30 feet above roadways or footways, or at an elevation above a roof greater than the distance from the edge of the roof, shall, if they require attendance while in position, be provided with substantial, safely accessible runways, ladders, or platforms from which all replacements and other necessary adjustments can be made. Provision for supporting workmen by safety belts should be made in the construction and installation of signs so located.

(b) **Inclosure of live parts.**—Electric signs outside buildings shall have no ungrounded current-carrying parts normally exposed to contact.

(c) **Grounding of noncurrent-carrying parts.**—The exposed noncurrent-carrying metal parts of a sign should be grounded if within reach of any grounded surfaces, including metal work of the building structure.

(d) **Control.**—Electric signs, located as in (*a*), shall be provided with switches arranged to entirely disconnect all ungrounded supply wires of the sign, and either located within sight of the sign or arranged so that they can be locked in the open position.

364. Connectors for Signs.

Electric signs with changeable connections shall be so arranged that the connections can be changed manually only by approved connectors. Approved connectors shall interrupt all ungrounded conductors of the circuit.

365. Isolating or Guarding Lamps in Series Circuits.

(a) **Elevation.**—Arc and incandescent lamps and other devices in series circuits, except in grounded circuits of which no part exceeds 150 volts to ground, shall be effectively isolated or suitably guarded.

NOTE.—Isolation will ordinarily be deemed sufficient when a vertical clearance of 8 feet is provided from floors or other ordinarily accessible places within buildings, of 10 feet from footways outside buildings, and of 15 feet from roadways. Horizontal clearance from windows, porches, and other spaces accessible to the general public should be not less than 3 feet.

(b) **Suspension of lamps.**—Lamps shall be securely supported, and the hanger, rope, chain, or other means of support shall be regularly and systematically inspected. All metal cable or chain supports for lamps shall be effectively insulated from the lamp or shall be permanently grounded. Metal chains or metal cables and other conducting parts used for lowering lamps in series circuits shall be grounded or interrupted by a suitable strain insulator, the minimum height of which from the floor or ground shall be 8 feet, whether the lamp is in position or lowered.

366. Safe Access to Arc Lamps.

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 suitable insulating stools, platforms, or tower wagons, and treated always as under the full voltage of the circuit concerned.

SEC. 37. PORTABLE DEVICES, CABLES, AND CONNECTORS

[Not including those for communication systems]

370. Insulation.

Portable devices shall be provided with an adequate dielectric (complying with the standardization rules of the American Institute of Electrical Engineers) interposed between ungrounded current-carrying parts and those external surfaces which persons can touch.

Exception.—Toasters, grills, or other heating devices in which the current-carrying parts at high temperature are necessarily exposed are exempted. (Compare rule 352.)

In locations where the dielectric is exposed to mechanical injury it shall be suitably protected.

371. Grounding of Frames.

(a) **When adjacent to grounded surfaces.**—The permanent grounding of frames of portable devices (especially in connection with voltages of more than 150 to ground, and for any voltage 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) is recommended as a safety measure.

NOTE.—Such grounding may be obtained by the use of a three-wire portable cord with the portable device, one wire being used for the grounding conductor and the connectors being properly designed so that wrong connections can not be made by the user of the device.

(b) **Sockets and fixtures of insulating material.**—In lieu of grounding the external metal parts of portable lamp sockets where suitable means (as above indicated) are not readily available, sockets and lamp guards or similar devices of suitable insulating material may be used, and should be used in the hazardous locations listed previously.

372. Cable Connectors.

(a) **Break all conductors.**—Where used with portable conductors, it is recommended that connectors be used which necessarily disconnect both or all poles from the live source of energy where the circuit is opened.

(b) **Design of connectors.**—Connectors shall be so constructed (with guards when necessary) that the person using them can not inadvertently come in contact with live parts or be burned by arcing when interrupting the largest current for which they are rated or marked.

Separable connectors should be so designed that the plugs will not fit receptacles rated for larger currents than the plugs.

(c) **Live parts of connectors.**—The end of a separable connector which is left alive, or the two ends of a separable connector where both are connected to live circuits (as in battery charging), shall have live parts suitably guarded.

(d) **Strain relief.**—Where connectors are attached to portable cables, suitable means shall be provided for relieving the terminal connections of cable from strains.

373. Identified Conductors, Cords, and Connectors.

(a) **Portable devices.**—Where portable devices have cases designed to be grounded and the connecting cable is provided with a separate grounding conductor for this purpose (see rule 371), such grounding conductor and the corresponding parts of connectors shall have suitable identification, so that the grounding conductor in fixed wiring and portable cable will always be connected to the proper terminals of the connectors.

(b) **Separable connectors.**—Separable connectors shall be so constructed that wrong connection between the two parts is impossible.

374. Use of Portables and Pendants.

(a) **Voltage limit of portables.**—Portable and pendent conductors shall not be installed or used on circuits operating at more than 300 volts to ground, unless they are accessible only to qualified persons. In such cases they shall be of a type suited to the voltage and conditions.

In car houses and similar locations where service at low voltage is not available and where necessary to use low-voltage pendent or portable lamps or other devices in series with lamps on trolley circuits, the devices should be used only with great caution and be placed preferably on the grounded side of the circuit concerned.

(b) **Use of fixed receptacles for portables.**—Where portable conductors are required, fixed 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.

(c) **Hazardous locations.**—Where exposed to dampness or corrosive influences, portable conductors shall be of a type specially suited, and where exposed to inflammable gas or flyings, they shall be so protected or isolated by elevation that they can not be readily damaged. In the latter case connectors shall be so arranged as not to be exposed to accidental opening by persons handling the portable conductors or devices. Portable lamps in locations where explosives or inflammable gases are normally present shall be incased in vapor-proof globes with suitable mechanical guards.

Portable lamps in damp places shall be equipped with a socket of noncombustible, nonabsorptive insulating material, an approved handle of nonabsorptive insulating material, a basket guard, and approved cord.

(d) **Strain relief.**—Portable and pendent conductors shall be so installed that no strain is placed on the terminal connections and shall have no joints except at suitable fittings.

(e) **Worn and defective portables.**—The use of worn or defective portable and pendent conductors should be avoided because of the danger to users by wire strands piercing the insulation or becoming exposed through abrasion of the covering.

SEC. 38. ELECTRICALLY OPERATED INDUSTRIAL LOCOMOTIVES, CARS, CRANES, HOISTS, AND ELEVATORS

380. Guarding Live and Moving Parts.

(a) **Guarding and isolation.**—All current-carrying parts accessible to unqualified persons which are connected to circuits of more than 150 volts to ground shall be so isolated or guarded that no person can inadvertently come in contact with them.

(b) **Conductors.**—All conductors of more than 150 volts to ground in locations accessible to the public shall be run in conduit, armored cable, metal molding, or flame-proof and waterproof nonmetallic ducts the exposed metallic parts of which shall be permanently grounded.

(c) **Elevator hoistways.**—Electric conductors installed in or under an elevator or counterweight hoistway shall, except for flexible cables connecting the car with the fixed wiring, be incased in metal conduits or armored cables and shall be securely fastened to the hoistway. No electrical conduit or cable, except such as is used to furnish or control power, light, heat, or signals for the elevator or hoistway, shall have any opening, terminal, outlet, or junction within the hoistway, but shall be continuous between outlets or terminals situated entirely outside the hoistway.

NOTE.—It is not intended to prohibit the interruption of long runs for the purpose of supporting or pulling in conductors, and pull boxes may be installed for this purpose.

All live parts of electric apparatus in elevator hoistways shall be protected against accidental contact by suitable inclosing casings or coverings, and all such casings or coverings which are made of metal shall be permanently grounded.

No part of any electric circuit whose voltage exceeds 750 volts shall be connected to any elevator car. It is recommended that signal circuits be restricted to 150 volts to ground. No signaling push buttons shall be used in circuits of more than 300 volts to ground. Circuits of higher voltage may be used in machine room or penthouse for the operation of motors, provided that all control and signal wiring is thoroughly insulated from the power circuit and all machine frames and metal hand ropes are permanently grounded.

(d) **Material for guards.**—Guards required by rule 306 and paragraph (*a*) of this rule for the current-carrying parts of unisolated electric equipment, such as controllers, motors, transformers, fuses, circuit-breakers, switches, and other devices, shall consist of cabinets, casings, or shields of permanently grounded metal or of substantial insulating material, or of a combination of the two. All metallic parts, such as conduits, apparatus cases, etc., which are liable to become charged shall be permanently and effectively grounded when so located that unqualified persons may come in contact with them.

(e) **Apparatus insulated and grounded.**—On passenger cars, apparatus, such as air-compressor motors, having insulated nongrounded mountings, shall be located where passengers are not liable to come in contact with them, as on the exterior of the car body. The air lines from non-grounded air compressors shall be provided with insulating joints in the line, insulating joints to be located in a substantially vertical pipe run in such a manner as to insulate from the motor all pipe or exposed apparatus with which passengers or crew may come in contact. Such pipe and apparatus shall be grounded.

(f) **Collector wires and third rail.**—Except on fenced rights of way or other locations to which only qualified persons are admitted, trolley or crane collector wires and third rails, whether indoors or out, shall be so isolated by elevation (see rule 114 and sec. 23) or be provided with suitable guards so arranged that persons can not inadvertently touch the current-carrying parts while in contact with the ground or with conducting material connected to the ground.

At locations where unqualified persons are especially exposed to possible contact, warning signs shall be provided.

Trolley contact conductors, indoors, shall be so supported that, in case of a single break, the lower end of the broken wire will not come within 8 feet of the floor.

NOTE.—Damp wood, concrete floors, and metal parts of crane cabs are considered as grounded.

(g) **Arcing or suddenly moving parts.**—All such parts of electric equipment, including fuses and the handles and arc chutes of circuit-breakers, shall be so isolated or guarded that the liability of persons being struck or burned by sparking, flashing, or movement during operation is avoided.

(h) **Removable headlights.**—Headlight frames shall not be used as conductors and portable headlights shall be wired for double-plug connections. All coupler connections shall be so designed and wired that when the coupler is pulled apart there will be no exposed live parts.

381. Grounding Noncurrent-carrying Parts.

(a) **Frames.**—All noncurrent-carrying metal parts of electric equipment of more than 150 volts to ground, accessible to unqualified persons, shall be permanently grounded or protected by permanently grounded guards or covers. In electric cars all steam or hot-water heating devices accessible to the public shall also be grounded.

NOTE.—The ground connection through well-bonded track rails will be considered satisfactory for equipment on cars and cranes.

(b) **Portable equipment.**—The metallic parts of portable cranes, derricks, hoists, and similar equipment on which wires, cables, chains, or other conducting objects are maintained should be provided with an effective protective ground (see sec. 9) where operated in the vicinity of supply lines of more than 150 volts to ground, whether the cranes or similar equipment are themselves electrically operated or not.

On the booms of cranes and derricks mounted on the tracks of railways with overhead trolley contact conductors an insulated barrier shall be provided which will prevent contact of conducting parts with the overhead wire if the boom is raised against it.

(c) **Guarding parts on car roofs.**—Metal parts of car which extend above the car roof (such as whistles or smoke pipes, heater expansion tanks, and metal ventilators) shall either be grounded or insulated or guarded by substantial guards or screens insulated from ground.

If insulated, the insulating joint shall be located immediately below the car roof. Insulating joints in air pipes shall be installed in a substantially vertical run of pipe.

382. Control of Energy Supply to Cars, Cranes, and Industrial Locomotives.

(a) **Disconnecting means.**—Readily accessible means shall be provided whereby all conductors and equipment, except lightning arresters, located in or on industrial locomotives, cars, or cranes can be disconnected entirely from the source of energy at a point as near as possible to the trolley or other current collectors, except on such equipments where the current collectors can be readily removed from the trolley or third rail.

(b) **Main switch or circuit-breaker.**—A circuit-breaker or switch, capable of interrupting the circuit under heavy loads, and readily controlled by the operator, shall be provided, unless the current collectors can be safely removed, under heavy loads, from the trolley or third rail.

(c) **Disconnector for third-rail collector.**—Where current supply is from two sources (such as overhead trolley and third rail) disconnecting switches shall be provided as follows:

(1) On a public right of way, a double-throw switch shall be provided in current-collector cable so arranged that when current supply is from either source the current-collector cable from the other source is disconnected.

(2) On a private right of way, a single-throw switch shall be provided in cable to third-rail collectors so that these may be deenergized when the current supply is from the overhead trolley.

383. Control of Movement of Industrial Locomotives, Cars, Cranes, and Elevators.

(a) **Locking or removable handles.**—Means shall be provided whereby the operator (whether motorman or elevator attendant) can prevent the starting of the equipment by unauthorized persons while he is absent from his post.

NOTE.—Removable reverse levers or controller handles and locked doors to the operator's cab or elevator hoistway are among the most effective means.

(b) **Location of controllers.**—The car control lever of passenger elevators should be located so that the operator can readily face the principal car opening. For cars and traveling cranes the car control should be so located that the operator can readily see in the direction of travel.

It is recommended that the control levers of traveling cranes be located in the same relative position each to the other in all the cages of cranes of any organization under a given management.

(c) **Limit switch.**—A limit switch shall be provided for the upper limit of travel of crane hoists and for both upper and lower limits of travel for elevators.

Limit switches shall be at least four (4) feet above lowest floor level in garages and other buildings where inflammable gases may be present.

(d) **Reverse-phase relays.**—Polyphase alternating-current motors operating freight or passenger elevators or cranes that are dependent upon phase relation for their direction of rotation shall be provided with a device, such as a relay, which will prevent starting any motor if the phase rotation is in the wrong direction. In the case of cranes this device may be inserted ahead of the runway feeders.

Exception is made in the case of a control having an operating device for the reversing switches which automatically changes its direction of operation when a change in phase rotation is made in the power circuit.

384. Subway and Car Lighting.

Subways and similar locations used for passenger transportation, where artificial illumination is indispensable, shall be lighted throughout their entire length by a system independent of the current for electric traction, where such is used. It is recommended that passenger cars operated in such locations and lighted normally from the railway circuit shall be equipped with an auxiliary system of emergency lighting.

SEC. 39. TELEPHONE AND OTHER COMMUNICATION APPARATUS ON CIRCUITS EXPOSED TO SUPPLY LINES OR LIGHTNING

390. Guarding Noncurrent-carrying Parts.

(a) **Protective requirements.**—Where telephone or other communication apparatus (not included under (*b*) below) which must be handled by persons is permanently connected (not including portable telephones) to overhead communication circuits exposed to lightning or to supply lines of more than 400 volts to ground, provision against shock to persons handling apparatus shall be made by one or more of the following methods:

(1) The use of suitable protective devices, such as fuses and arresters, and for conditions of unusual exposure, drainage coils or transformers, or both.

(2) The grounding of all exposed noncurrent-carrying metal parts and the suitable guarding of all ungrounded current-carrying parts. (See rule 391.)

(3) The arrangement of apparatus in such a way that persons using it will be obliged to stand on a suitably insulated platform in a suitably insulated booth, or on other insulating surfaces. (The above applies only where apparatus is accessible to none but authorized persons.)

(4) The arrangement of apparatus (on communication circuits exposed to supply lines of more than 750 volts to ground) so as to have no exposed current-carrying parts exceeding 2 square inches in area with which a person is liable to come in contact and the use of suitable protective devices, including fuses and arresters or other means.

(b) **Fire and police alarm boxes.**—Such signaling devices as fire and police alarm boxes and telegraph test boxes, if connected to overhead communication circuits exposed to lightning or to supply lines of more than 400 volts to ground, should have the accessible noncurrent-carrying metal parts permanently grounded wherever the character of service gives valid objection to the use of arresters or transformers on the signal circuit.

Police-alarm boxes, where connected to overhead police-alarm circuits, should be protected by arresters operating at 500 volts to ground, placed in the connecting leads outside the box.

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 7,500 volts.

391. Guarding Current-carrying Parts.

(a) **Current-carrying parts.**—Telephone or other communication devices which are permanently located outdoors or where exposed to corrosive fumes or dampness (such as may occur in subways, cellars, basements, laundries, stables, etc.) shall be so arranged that all ungrounded current-carrying parts are so guarded as to be suitably protected against the prevailing atmospheric conditions.

The inclosing cases of communication apparatus provide suitable guards if substantially built of metal or insulating materials.

(b) **Receiver cords.**—Receiver cords shall be guarded by shields of permanently grounded metal (such as metal armor) or of nonabsorptive insulating material (such as flexible insulating tubing), or shall have suitable insulating coverings for the individual conductors.

(c) **Shields for portable cords.**—Where no protective device is installed (permissible only for fire-alarm or similar apparatus or for apparatus not for public use where the character of service precludes the use of arresters and fuses) the shields of portable cords shall always be of grounded metal or of special insulating material suitable to withstand the voltage of the highest-voltage supply circuit to which the communication circuit is exposed up to 7,500 volts.

392. Protection Against Induced Voltages.

All telephone or other communication equipment which must be handled by persons, and which is connected to a line that parallels a supply circuit in such manner that by reason of exposure to the supply circuit under normal conditions more than 150 volts are induced between the terminals of the communication equipment and ground, shall be protected by one or more of the following means:

(1) All exposed metal parts of the equipment shall be insulated from the circuit, and the circuit shall be protected by arresters having a 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.

(2) All exposed noncurrent-carrying metal parts shall be permanently grounded, and all current-carrying metal parts shall either be permanently grounded or adequately shielded. (See rule 391.)

(3) All equipment shall be so located that persons coming into contact with the equipment shall be obliged to stand either on an insulated platform or in a booth of suitable insulating material. (See rule 390 (*a*) (3).)

393. Grounding of Arresters for Communication Systems.

The ground connections for outside installations of cable protectors employed solely to prevent electrical injury to

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the cable need not conform with the requirements of this rule. For rules governing the grounding of the metal cases of outdoor apparatus as covered by this section see section 9.

(a) **Methods.**—Arresters shall be permanently and effectively grounded in the following manner:

(1) The grounding conductor shall preferably be of copper (or other material which will not corrode under the conditions of use) and shall be not less than No. 18 (0.040 inch) in size, and in urban districts or where within buildings shall be covered with a suitable insulation.

If necessary to guard the grounding conductor from mechanical injury (on poles or where a grounding conductor on the outside of building walls is near a roadway, sidewalk, or pathway, thus necessarily exposing it to tampering by unauthorized persons), it shall be protected for a distance of 8 feet from the ground by a wooden molding or by conduit of nonmagnetic material.

(2) The ground connection shall be made to a cold-water pipe, where available, connected to the street mains and in service. An outlet pipe from a water tank fed by a street main may be used provided such outlet pipe is adequately bonded around the tank to the inlet pipe connected to the street main.

If a cold-water pipe is not available, the ground connection may be made to a gas pipe, provided the grounding conductor is attached to the pipe between the meter and the street mains.

If cold-water or gas pipes are not available, the ground connection may be made to an iron rod or pipe driven into permanently damp earth, or to a plate or other body of metal buried in permanently damp earth. (Compare rule 93.)

Steam or hot-water pipes should not be used for ground connections.

Driven rods or pipes used as ground connections for protectors shall not be also used as ground connections for electric supply circuits or electric apparatus, and where water or gas pipes are used for a ground connection, attachment to such pipes shall be made at a different point than for attachments to electric supply circuits or equipment.

(b) **Connecting grounding conductor to pipes.**—Grounding conductors shall be attached to pipes by means of suitable ground clamps; the entire surface of the pipe to be covered by the clamp shall be thoroughly cleaned.

(c) **Connecting grounding conductor to driven rod or pipe.**—The grounding conductor shall be so attached to the rod or pipe as to give reliable connection both mechanically and electrically and in such a manner as to prevent corrosion when the joint is buried in the earth.

(d) **Connecting grounding conductor to buried electrode.**—Where buried plate or other metal electrode is employed, the grounding conductor shall be securely fastened to it in such manner as to make a reliable electrical and mechanical contact.

PART 4. RULES TO BE OBSERVED IN THE OPERATION OF ELECTRICAL EQUIPMENT AND LINES

CONTENTS

SEC. 40. SCOPE AND APPLICATION

400. Scope.

A. Sections 41 to 43.—The safety rules in sections 41, 42, and 43 do not apply to new construction not yet energized, but apply to the operation of, or to work on or about, the following:

1. Supply lines.
2. Communication lines used in connection with supply lines.
3. Electrical equipment of central stations, substations, and private plants.
4. Electrical tests.
5. Electrical work in tunnel, subway, or similar underground structures.

B. Sections 44 and 45.—The safety rules in these sections apply to commercial telephone and telegraph, and other communication equipment and lines, with terminology adapted to the special needs of the employees concerned. Communication equipment and lines include fire and police alarm systems, district messenger systems, and other communication systems not operated in connection with supply lines.

401. Application.

While all the rules find application in the larger industrial or private plants and in moderate-sized utilities, some do not apply, or apply less fully, in the smaller ones. It has seemed unwise, however, to attempt to restrict the scope of these rules to rules which are applicable to all organizations or to all classes of electrical work.

402. Exposed Communication Lines.

Communication equipment and lines are not considered alive, except where made alive by leakage from supply equipment or lines. They are, however, a source of danger when near live supply lines, due to their liability of being grounded.

SEC. 41. SUPPLY SYSTEMS—RULES FOR EMPLOYERS

410. General Requirements.

A. Interpretation and enforcement of rules.

1. *Distribution.*—The employer shall furnish to each regular employee operating or working on electrical supply equipment, supply or communication lines, or hazardous electrical tests a copy of these safety rules for operation (or such of these rules as apply to his work), either separately or incorporated in more comprehensive rule books, and shall take means to secure the employee's compliance with the same.

NOTE.—Many companies number their books of rules and require a receipt from each employee for his copy.

2. *Interpretation.*—If a difference of opinion arises with regard to the meaning or application of these rules or as to the means necessary to carry them out, the decision of the employer or his authorized agent shall be final, unless an appeal is taken to the regulative body having jurisdiction.

3. *Modification.*—Cases may arise where the strict enforcement of some particular rule will seriously impede the progress of the work in hand; in such cases the employee in charge of the work to be done may, with the consent of the chief operator concerned, make such temporary modification of the rule as will expedite the work without materially increasing the hazard.

B. Organization diagram.—An organization diagram or written statement clearly showing the division of responsibility between officials and employees, down to and including the grade of foreman, should be supplied with the book of rules, or the rules should be posted conspicuously in offices and stations of the employer and in other places where the number of employees and the nature of the work warrants.

C. First-aid rules and physicians' addresses.—The rule book should contain or be accompanied by the following

1. A list of names and addresses of those physicians and members of the organization who are to be called upon in emergencies.

2. A copy of rules for first aid, prone-pressure method of resuscitation and fire extinguishment. These should also be kept in conspicuous locations in every station and testing room, in line wagons, and in other places where the number of employees and the nature of the work warrants.

D. Instructing employees.—Employees regularly working on or about equipment or lines shall be thoroughly instructed in methods of first aid, resuscitation by the prone-pressure method, and, where advisable, in fire extinguishment.

E. Qualifications of employees.—The employer shall use every reasonable means and precaution to assure himself that each employee is mentally and physically qualified to perform his work in accordance with these rules.

F. Chief operator.

1. *Authority.*—A properly qualified chief operator, system operator, load dispatcher, general superintendent, or otherwise designated employee shall be in charge of the operation of electrical equipment and lines and directly responsible for their safe operation. His duties shall be those prescribed in rule 421, A.

2. *Deputy.*—In large organizations the duties of the chief operator may be delegated for any particular section of the

system to a deputy chief operator (or otherwise designated employee) who shall report as required to the chief.

3. *Large organizations or extended systems.*—When it is impracticable to have the entire system placed in charge of one chief operator, the duties of the chief operator may be performed by a local superintendent, local manager, or other employee who may also perform other duties.

4. *Small organizations.*—The duties of the chief operator in small organizations may be performed for a portion of the system by a local superintendent, electrician, engineer, or some other employee who may also perform other duties.

NOTE.—In these rules the various employees listed by above titles, including the deputy chief operator, will be designated (for simplicity) by the title of chief operator, where referred to in this capacity.

G. Responsibility.—If more than one person is engaged in work on or about the same electrical equipment or lines at any one location, one of the persons shall be designated as the foreman locally in charge of the work; or, all of the workmen shall be instructed as to the work they are to perform, and the employee instructing the workmen shall be considered in charge of the work.

411. Protective Methods.

A. Attendance.—Unless a qualified employee is kept on duty where generators or rotary converters are operating, such equipment shall be made inaccessible to unauthorized persons.

B. Requirement for two workmen.—In wet weather or at night, at least two workmen should be assigned where the work is on or dangerously near live lines of more than 750 volts.

Exception.—Trouble or emergency work is excepted.

C. Unqualified workmen and visitors.—Unqualified employees or visitors shall be prohibited from approaching any live parts, unless accompanied by a qualified employee.

D. Diagrams for chief operator.—Diagrams or equivalent devices, showing plainly the arrangement and location of the electrical equipment and lines, should be maintained on file or in sight of the chief operator.

NOTE.—These diagrams may be of the entire system, or of each specific portion of the system, or they may show typical arrangements.

E. Instructions to employees.—All employees shall be instructed as to the character of all equipment or lines on or dangerously near to which work must be done by them. Instructions shall describe the equipment and lines to be worked on, identifying them either by position, letter, color, number, or name.

F. Protective devices.—A supply of suitable protective, first-aid, and fire-extinguishing devices and equipment, sufficient to enable employees to meet the requirements of these rules, shall be provided in conspicuous and suitable places in electrical stations, testing departments, and line construction and repair wagons.

The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case:

1. First-aid outfits.

2. Insulating wearing apparel, such as insulating gloves, sleeves, and boots. Insulating shields, covers, mats, stools, and platforms. Insulating appliances, such as rods and tongs, for any necessary handling or testing of live equipment or lines.

3. Protective goggles of suitable materials and construction.

4. Tools of such special design and insulation as to eliminate so far as practicable the danger of forming short-circuits across conducting parts at different potentials or bringing the user into circuit with such parts.

5. "Men at work" tags, log books, operation diagrams or equivalent devices, and portable danger signs.

6. Fire-extinguishing devices, either designed for safe use on live parts or plainly marked that they must not be so used.

7. Grounding devices for making protective grounds.

G. Inspection of protective devices.—Such devices and equipment shall be inspected or tested to insure that they are kept in good order. Safety belts, whether furnished by employer or employee, should be inspected from time to time to assure that they are in safe working condition.

H. Warning signs.—Permanent warning signs forbidding entrance to unauthorized persons shall be displayed in conspicuous places at all unattended and unlocked entrances to electrical supply stations, substations, and testing rooms containing exposed current-carrying parts or moving parts

I. Danger signs.—Suitable danger signs shall be placed in, supply stations, substations, switching towers, and testing rooms about equipment having exposed current-carrying parts of more than 750 volts.

SEC. 42. SUPPLY SYSTEMS—GENERAL RULES FOR ALL EMPLOYEES

420. General Precautions.

A. Rules and emergency methods.—The safety rules should be carefully read and studied. Employees may be called upon at any time to show their knowledge of the rules.

Employees should familiarize themselves with approved methods of first-aid, resuscitation, and fire extinguishment.

B. Heeding warnings, warning others.—Employees whose duties do not require them to approach or handle electrical equipment and lines should keep away from such equipment or lines.

They should cultivate the habit of being cautious, heeding warning signs and signals, and always warning others when seen in danger near live equipment or lines.

C. Inexperienced or unfit employees.—No employee shall do work for which he is not properly qualified on or about live equipment or lines.

Exception.—Work done under the direct supervision of an experienced and properly qualified person is excepted.

D. Supervision of workmen.—Workmen, whose employment incidentally brings them in the vicinity of electrical supply equipment or lines with the dangers of which they are not familiar, shall proceed with their work only when authorized. They shall then be accompanied by a properly qualified and authorized person, whose instructions shall be strictly obeyed.

E. Exercising care.—Employees about live equipment and lines should consider the effect of each act and do nothing which may endanger themselves or others. Employees should be careful always to place themselves in a safe and secure position and to avoid slipping, stumbling, or moving backward against live parts. The care exercised by others should not be relied upon for protection.

F. Live and arcing parts.

1. *Treat everything as alive.*—Electrical equipment and lines should always be considered as alive, unless they are positively known to be dead. Before starting to work, preliminary inspection or test should always be made to determine what conditions exist. (See rule 422, A, for general requirements and rule 424, C, for test of circuit.)

2. *Protection against arcs.*—The hands should be covered by protecting and insulating gloves and the eyes by suitable goggles or other means if exposed to injurious arcing. Either a thin rubber glove used with a protective outer glove or a heavier rubber glove used alone shall be considered as both protecting and insulating.

Employees should keep all parts of their bodies as far away as possible from brushes, commutators, switches, circuit-breakers, or other parts at which arcing is liable to occur during operation or handling.

G. Safety appliances.—Employees at work on or near live parts should use the protective devices and the special tools provided. Before starting work these devices or tools should be examined to make sure that they are suitable and in good condition.

NOTE.—Protective devices may get out of order or be unsuited to the work in hand.

H. Suitable clothing.—Employees should wear suitable clothing while working on or about live equipment and lines. In particular, they should keep sleeves down and avoid wearing unnecessary metal or inflammable articles, such as rings, watch or key chains, or metal cap visors, celluloid collars, or celluloid cap visors. Loose clothing and shoes that slip easily should not be worn near moving parts.

I. Safe supports.—Employees should not support themselves on any portion of a tree, pole structure, scaffold, ladder, or other elevated structure without first making sure that the support is strong enough. Supports should be reinforced if necessary.

Conducting paint should not be used in painting portable ladders. Portable ladders should not be reinforced longitudinally with metal when used in electrical stations.

Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the supporting surfaces are smooth or vibrating.

J. Safety belts.—Employees working in elevated positions should use a suitable safety belt or other adequate means to guard against falling. Before an employee trusts his weight to the belt, he should determine that the snaps or fastenings are properly engaged and that he is secure in his belt. Any employee who furnishes his own belt shall from time to time submit it to his employer for inspection.

K. Fire extinguishers.—Employees should avoid using fire-extinguishing liquids which are not insulating in fighting fires near exposed live parts. If necessary to use them, all neighboring equipment should first be killed.

L. Repeating messages.—Each person receiving an unwritten message concerning the handling of lines and equipment shall immediately repeat it back to the sender and secure his full name and acknowledgment. Each person sending an unwritten message shall require it to be repeated back to him by the receiver and secure the latter's full name.

421. Operating Routines.

A. Duties of chief operator.—The chief operator, described in rule 410, F, shall—

1. Keep informed of all conditions affecting the safe and reliable operation of the system.

2. Keep a suitable record or log book showing all changes in such conditions. He shall read and sign such record when assuming duty and sign again on being relieved.

3. Keep within sight operating diagrams or equivalent devices indicating whether electrical supply circuits are open or closed at stations under his immediate jurisdiction and where work is being done under his special authorization.

Exception.—These indicating devices shall not be required for any chief operators classed under paragraphs 3 and 4 of rule 410, F, if the record or log sheets show all conditions affecting the safe and reliable operation of the system.

NOTE.—In these rules the person performing these duties is designated as chief operator, regardless of his ordinary title.

B. Duties of foreman.—Each foreman in charge of work shall adopt such precautions as are within his power to prevent accidents and to see that the safety rules are observed by the employees under his direction. He shall make all the necessary records and shall report to his chief operator when required. He shall, as far as possible, prevent unauthorized persons from approaching places where work is being done. He shall also prohibit the use of any tools or devices unsuited to the work in hand or which are so defective or in such poor condition as to make them unsafe.

C. Qualified guides.—The qualified persons accompanying uninstructed workmen or visitors near electrical equipment or lines shall take precautions to provide suitable safeguards and see that the safety rules are observed.

D. Special authorization.

1. *Special work.*—Special authorization from the chief operator shall be secured before work is begun on or about station equipment, transmission or interconnected feeder lines or live lines of more than 7,500 volts, and in all cases where lines are to be killed by regular procedure at stations, and a report shall be made to him when such work ceases.

Exceptions.—In emergency, to protect life or property, or when communication with the chief operator is difficult due to storms or other causes, any qualified employee may make repairs on or about the equipment or lines covered by this rule without special authorization if the trouble is such as he can promptly clear with help available in compliance with the remaining rules. The chief operator shall thereafter be notified as soon as possible of the action taken. (See rule 421, H, 2, for crossed or fallen wires.)

2. *Operations at stations.*—In the absence of specific operating schedules for opening and closing supply circuits at stations, or starting and stopping equipment, employees shall secure special authorization from the chief operator before performing these operations. In all cases such special author-

ization shall be secured where circuit or equipment control devices are tagged at stations to protect workmen. (See rule 421, F, for tagging electrical circuits.)

Exceptions.—In emergency, to protect life or property, any qualified employee may open circuits and stop moving equipment without special authorization if, in his judgment, his action will promote safety, but the chief operator shall be notified as soon as possible of such action, with reasons therefor. To maintain service, any qualified employee may also reclose circuits which have been opened by fuses or automatic circuit-breakers except where this is prohibited by rule.

3. *Cutting out sections of circuits.*—Special authorization shall be secured from the chief operator before sections of overhead or underground circuits are cut off by employees at points other than at stations by means of sectionalizing switches.

Exception.—Portions of distribution circuits of less than 7,500 volts may be cut off by authorized employees without special authorization from the chief operator, by means of sectionalizing switches, if the chief operator is thereafter notified as soon as possible of the action taken. This may also be done even for circuits of more than 7,500 volts when communication with the chief operator is difficult.

E. **Restoring service after work.**—No instructions for making alive equipment or lines which have been killed by permission of the chief operator to protect workmen shall be issued by him until all workmen concerned have been reported clear. When there is more than one workman at a location, a person authorized for the purpose shall report clear for such workmen, but only after all have reported clear to him. If there is more than one gang, each shall be so reported clear to the chief operator.

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F. Tagging electrical supply circuits.

1. *When tags are placed at direction of chief operator.*—Before work is done at direction of chief operator on or about equipment or circuits under any of the following conditions, the chief operator shall have "Men at work" tags attached at all points where such equipment or circuits can be manually controlled by regular operators. The tags should be placed to plainly identify the equipment or circuits worked on.

(*a*) Transmission or interconnected feeder circuits.

(*b*) Circuits operating at more than 7,500 volts.

(*c*) Circuits killed at stations and substations to protect workmen.

2. *When tags are placed at direction of authorized employees.*—Before work is done on or about any equipment or lines which are killed by authorized employees at points other than at stations, the employees shall have "Men at work" tags placed at all points where the circuit has been disconnected to identify the portion worked on.

G. Maintaining service.

1. *Closing tagged circuits which have opened automatically.*—When live circuits on which "Men at work" tags have been placed have opened automatically, they should be kept disconnected until the chief operator has given proper authorization for reconnection.

2. *Closing circuits operated automatically.*—When overhead circuits, other than trolley and third-rail circuits, open automatically, the employer's local operating rules shall determine in what manner and how many times they may be closed with safety for persons on or near those circuits. The chief operator shall be advised of the conditions.

3. *Grounded circuits.*—When circuits feeding supply lines become accidentally grounded, they shall be tested to deter-

mine where the ground exists. If the ground can not be definitely located and removed by the station operator, an immediate report of the finding shall be given to the chief operator, who shall order a patrol of the lines affected to definitely locate and remove the ground as soon as practicable.

NOTE.—On circuits exceeding 7,500 volts it will usually be found advisable to disconnect the circuit or effectively ground the accidentally grounded conductor until the lines have been cleared of the accidental ground.

H. Protecting traffic.

1. *Barrier guards.*—Employees shall first erect suitable barrier guards before engaging in such work as may endanger traffic. They shall also display danger signs or red lamps placed so as to be visible to traffic approaching from any direction. A man shall be stationed to warn passers-by while work is going on where the nature of work and traffic requires it.

2. *Crossed or fallen wires.*—An employee finding any crossed or fallen wires which may create a hazard shall remain on guard or adopt other adequate means to prevent accidents, and shall have the chief operator notified. If the employee can observe the rules for handling live parts by the use of insulating appliances, he may correct the condition at once; otherwise he shall first secure the authorization from the chief operator for so doing. (See rule 421, D, for special authorization.)

I. Protecting workmen by switches and disconnectors.—When equipment or lines are to be disconnected from any source of electrical energy for the protection of workmen, the operator shall first open the switches or circuit-breakers designed for operation under load, and then the air-break disconnectors, when provided.

422. Handling Live Equipment or Lines.

A. General requirements.

1. *Touching live parts.*—An employee should never touch with bare hands two parts at different potential at the same time. He should never touch with bare hands even a single exposed ungrounded live part at a dangerous potential to ground unless he is insulated from other conducting surfaces, including the ground itself, and stands on insulating surfaces.

2. *Wire insulation.*—Employees should not place dependence for their safety on the insulating covering of wires. All precautions in this section for handling live parts shall be observed in handling insulated wires.

NOTE.—Insulation on a wire may look perfect, but it frequently will not prevent shock.

3. *Exposure to higher voltages.*—Every employee working on or about equipment or lines exposed in overhead construction to voltages higher than those guarded against by the safety appliances provided should as far as practicable assure himself that the equipment or lines worked on are free from dangerous leakage or induction or have been effectively grounded.

4. *Cutting into insulating covering of live conductors.*—When the insulating covering on live wires or cable must be cut into, the employee should use a suitable tool.

Recommendation.—While doing such work, it is recommended that suitable goggles be worn to protect the eyes, and insulating gloves to protect the hands.

When metal sheathing must be removed from cables, it should be done with special tools which will not injure the insulation. The sheathing should be cut so as to leave enough exposed insulation after the conductor has been bared to avoid arcing over between the conductor and the sheath. If the cable consists of more than one conductor, similar exposed insulating surface should be left for each conductor, using insulating separators between conductors, if necessary. Insulating devices, such as wood separators, etc., should be examined, and conducting dust or chips, sharp edges, or nails should be eliminated to avoid defeating the purpose for which the devices are intended.

5. *Metal tapes or ropes.*—Metal measuring tapes and tapes, ropes, or hand lines having metal threads woven into the fabric should not be used near exposed live parts.

6. *Metal-reinforced ladders.*—Ladders reinforced by metal in a longitudinal direction should not be used near exposed live parts.

B. Avoiding shock—Voltages between 750 and 7,500.—No employee should go, or take any conducting object without a suitable insulating handle, within 6 inches of any exposed live part whose voltage exceeds 750, where it is practicable to avoid this.

Where safe distance from live parts can not be secured by use of the special insulating tools and appliances furnished, properly tested insulating gloves and sleeves may serve as the sole portable insulating devices between the person and live parts.

Exception 1.—In dry locations this distance may be less than 6 inches if insulating devices, such as shields, covers, or gloves, are placed between the person and the part or object.

Exception 2.—In dry locations the distance may also be reduced if insulating barriers (such as mats, stools, or platforms) are placed between the person and the ground, and suitable insulating shields between the person and all other conducting or grounded surfaces which he could accidentally touch at the same time.

Exception 3.—In all damp or dark locations the distance may be less than 6 inches only if insulating devices are used between the person and the live parts and also between him and all other conducting surfaces with which he might otherwise come in contact at the same time.

Note.—Care should be exercised in using insulating gloves to avoid puncturing them on sharp edges, especially in making wire splices. It is sometimes advisable to wear protecting gloves over insulating gloves.

C. Avoiding shock—Voltages exceeding 7,500.

1. *Clearances from live parts.*—No employee should go, or take any conducting object, within the distances named below from any exposed live part at or above the voltage specified.

Clearance from live parts

Operating voltage:	Distance in feet
7,500	1
15,000	2
50,000	3
70,000	5

Distances for intermediate voltages to be determined by interpolation.

Exception.—In dry locations these distances may be reduced if suitable insulating guards or barriers are placed between the person and such part or object.

2. *Guards.*—If the part is being directly worked on, the tools or other mechanical appliances used shall have insulating handles of sufficient length to permit the operator to maintain the distance specified in rule 422, C, 1, preceding.

Exception.—This does not apply if protective guards are also used between the person and the live part.

Note.—These protective guards may be permanent insulating covers or shields, or may be disks of insulating material, suitable for the voltages to be handled and for the attendant conditions, attached to the handles of rods or tools.

D. Requirement for two workmen.—In wet weather or at night no employee shall work alone on or dangerously near live lines of more than 750 volts.

Exception.—Trouble and emergency work is excepted.

E. When to kill parts.—An employee shall not approach, or willingly permit others to approach, any exposed ungrounded part normally alive closer than permitted by rule 422, A, B, or C, unless the supply equipment or lines are killed.

NOTE.—This is to insure the employee of his own safety and the safety of those working under his direction.

F. Opening and closing switches.—Manual switches and disconnectors should always be closed by a single unhesitating motion, and, if possible, with one hand. Care should be exercised in opening switches to avoid causing serious arcing.

G. Work from below.—Employees should avoid working on equipment or lines from any position by reason of which a shock or slip will tend to bring the body toward exposed live parts. Work should, therefore, generally be done from below rather than from above.

H. Attaching connecting wires and grounds.

1. *Handling connecting lines.*—In connecting dead equipment or lines to a live circuit by means of a connecting wire or device, employees should first attach the wire to the dead part before attaching it to the circuit. When disconnecting, the live end should be removed first. Loose conductors shall be kept away from exposed live parts.

2. *Applying grounds.*—In applying a grounding device to normally live parts, the device shall be grounded before being brought near the parts and shall be removed from the live parts before being removed from the ground connection.

I. Handling series circuits.—Secondaries of current transformers to meters or other devices should not be opened when alive until a jumper has been connected across the point of opening or the circuit has been short-circuited elsewhere.

Before working on arc lights connected to series circuits, they shall be short-circuited or (when necessary to avoid hazard) disconnected entirely from such circuits by absolute cut-outs.

J. Stringing wires.—In stringing wires near live conductors, they should be treated as alive unless they are effectively grounded.

423. Killing Equipment or Lines.

A. Application of rule.—Where workmen must depend on others for operating switches to kill circuits on which they are to work or must secure special authorization from the chief operator before themselves operating such switches, the following precautionary measures shall be taken in the order given, before work is begun on or about the equipment or lines concerned, as a means for preventing misunderstanding and accident.

In small organizations the chief operator may himself operate the switches and disconnectors instead of instructing others to do so, thus much simplifying and abbreviating the procedure. In certain cases the chief operator may direct the workman who wishes the section killed for his own protection to operate some or all switches necessary himself, thus also abbreviating the procedure.

In cases where there is no station with regular attendants at either end of a section of line to be killed for the protection of workers, the rules below need not apply for disconnection of that end of the section concerned, provided that the employee under whose direction that end of the section is disconnected is in sole charge of the section and of the means of disconnection employed or that the point of disconnection at that end of the section is suitably tagged before work proceeds.

B. Workman's request.—The workman in charge of the work shall apply to the chief operator to have the particular section of equipment of lines killed, identifying it by position, letter, color, number, or other means.

C. Opening disconnectors and tagging.—The chief operator at his discretion shall direct the proper persons to open all switches and air-break disconnectors through which electrical energy may be supplied to the particular section of equipment and lines to be killed and shall direct that such switches and disconnectors be tagged with a tag of a distinctive character indicating that men are at work. All oil switches and remotely controlled switches should also be blocked where necessary for avoiding mistakes.

A record shall be made when placing the tag, giving the time of disconnection, the name of the man making the disconnection and the name of the workman who requested the disconnection, and the name of the chief operator.

Where the section of equipment or lines can be made alive from two or more sources, all such sources shall be disconnected.

NOTE.—This will apply to work on lines with more than one station; also sometimes to work on transformers in banks, rotary converters, motor generators, switches, and on other similar equipment.

D. Station protective grounds.—When all the switches and disconnectors designated have been opened, blocked, and tagged in accordance with rule 423, C, the chief operator shall require that protective grounds be made upon the lines which have been killed and that they are reported to him when placed.

Exception.—This requirement does not apply under conditions where the making of such grounds will itself be more hazardous than working on lines without grounding.

E. Permission to work.—Upon receipt of information from all persons operating switches and disconnectors that protective grounds are in place, the chief operator shall advise the workman who requested the killing of the section that the specified section of equipment or line has been killed and that he may proceed to work.

F. Workmen's protective grounds for overhead lines.—The workman in charge should immediately proceed to make his own protective grounds on the disconnected lines, except under conditions where the making of such grounds will itself be more hazardous than working on the lines without grounding. Such grounds shall be made between the particular point at which work is to be done and every source of energy.

G. Proceeding with work.—After the equipment or lines have been killed (and grounded, if required by F above), the workman in charge and those under his direction may proceed with work on the grounded or killed parts. Care, however, shall be taken to guard against adjacent live lines or parts.

H. Procedure for other gangs.—Each additional workman in charge desiring the same equipment or lines to be killed for the protection of himself or the men under his direction shall follow the same procedure as the first workman and secure similar protection.

I. Reporting clear — Transferring responsibility.— The workman in charge, upon completion of his work, and after assuring himself that all men under his direction are in safe positions, shall remove his protective grounds and shall report to the chief operator that all tags protecting him may be removed, and shall give his location and report as follows: "Mr. ——— and men clear and all grounds removed."

The workman in charge who received the permission to work may transfer this permission and the responsibility for men under him, as follows:

He shall personally inform the chief operator of the proposed transfer, and if this is permitted, the name of the successor be entered at that time on the tags concerned or in the records of the persons placing the tags and of the chief operator. Thereafter the successor shall report clear and shall be responsible for the safety of the original workmen, so far as this is affected by the removal of tags.

J. Removal of tags.—The chief operator shall then direct the removal of tags for that workman, and the removal shall be reported back to him immediately by the persons removing them. Upon the removal of any tag, there shall be added to the record the name of the chief operator and workman who requested the tag, the time of removal, and the signature of the person removing the tag.

K. Restoring service.—Only after all protecting tags have been removed by the above procedure from all points of disconnection shall the chief operator, at his discretion, direct the removal of protective grounds and blocks and the closing of any or all disconnectors and switches.

424. Making Protective Grounds.

A. Application of rule.—When making temporary protective grounds on a normally live circuit, the following precautionary measures shall be observed in the order given, and the ground shall be made to all wires of the circuit which are to be considered as grounded:

B. Ground connections.—The employee making a protective ground on equipment or lines shall first connect one end of grounding device to an effective ground connection supplied for the purpose.

C. Test of circuit.—The normally live parts which are to be grounded should next be tested for any indication of voltage, the employee carefully keeping all portions of his body at the distance required from such parts when alive by the use of suitable insulating rods or handles of proper length, or other suitable devices.

D. Completing grounds.—If the test shows no voltage, or the local operating rules so direct, the free end of the grounding device shall next be brought into contact with the normally live part and securely clamped or otherwise secured thereto before the employee comes within the distances from the normally live parts specified in rule 422, B and C, or proceeds to work upon the parts as upon a grounded part.

In stations, remote-control switches can sometimes be employed to connect the equipment or lines being grounded to the actual ground connection. On lines it is generally necessary to resort to portable grounding devices or chains handled directly by means of insulating handles, rods, or ropes.

E. Removing grounds.—In removing a protective ground the employee shall not remove the grounding device from the ground connection until the device has been disconnected from all normally live current-carrying parts.

SEC. 43. SUPPLY SYSTEMS—RULES FOR EMPLOYEES DOING SPECIALIZED WORK

430. Supply Stations and Switchboards.

A. Application of rule.—Engineers, machine attendants, switchboard operators, and helpers shall study and strictly observe the following, in addition to all the general rules 420 to 424 which apply to their work:

B. Care about machines.—Do not allow oil cans, tools, dusters, or wiping cloths to catch in moving parts of machinery. In passing any switchboard or machine in operation, do not touch it unnecessarily nor allow metal tools or other metal objects to touch the apparatus or connections. Do not use iron or tin oil cans near field magnets, and use only dusters and wipers with insulating handles on or about exposed live parts. Employees about to work on normally moving parts of remotely controlled equipment during periods of rest shall be protected against their accidental starting by "Men at work" signs first being placed on the starting devices, and by locking or blocking these where practicable. All employees shall, before starting any work, satisfy themselves that all these protective devices have first been installed. (See rule 423.)

C. Care about live or moving parts.—Do not work on or near exposed live or moving parts unless authorized to do such work, and then strictly observe the rules applying.

When working near fuses and circuit-breakers or other apparatus which may arc suddenly be careful to avoid injury from their operation.

When working on one section of a switchboard or in one compartment, mark it conspicuously and place barriers to prevent your accidental contact with live parts in that section or adjacent sections.

When working on or about live parts and standing on insulated stools or ladders, or when otherwise insulated from the ground, avoid handing metal tools or other objects to other persons who are not insulated.

D. Handling fuses or brushes.—In handling fuses of more than 750 volts, use the special rods or tongs and stand on insulating platforms or mats, where provided. Keep the body as distant and as far below as possible.

Replace or remove link fuses from live terminals and handle brushes on live equipment only when absolutely necessary, and then with due precautions.

E. Battery rooms.—Do not smoke or cause arcing in storage-battery rooms. The use of open flames should be avoided, especially while the cells are gassing, and should be permitted only in special cases under the direct supervision of an experienced person and after the room has been thoroughly ventilated.

Do not handle live parts of batteries or their connections unless standing on insulating platforms or wearing suitable insulating boots.

F. Working in elevated positions.—When working in an elevated position, especially above live or moving parts, assure yourself of the security of your position and support, and take precautions to avoid dropping tools or materials.

G. Handling switchboard equipment.—All ungrounded metal parts of devices on switchboards shall be handled as if operating at the highest voltage to which any portion of the equipment on the same switchboard panel is subject, unless the parts are known, by test or otherwise, to be free from such voltage.

When cable plug connectors are used, do not allow one end to remain hanging loose while the other end is connected to a live terminal.

In handling instrument circuits, the secondary of a current transformer should never be opened when it is alive.

H. Reporting circuit trouble to chief operator.—Report to your immediate superior or to the chief operator any unusual conditions of load and the indication of any accidental ground on an outgoing circuit.

I. Reporting defects.—Promptly report to your superior any dangerous conditions of equipment or surroundings, including defective tools, switches, or protective devices, or live cases or frames of apparatus or instruments.

431. Meters.

A. Application of rule.—All meter setters and testers shall study and strictly observe the following in addition to all the general rules in 420 to 424 which apply to their work.

B. Taped joints.—Never leave joints or loose ends of wires untaped unless otherwise protected.

C. Care about live parts.—Do not use bare fingers or hands to determine whether a circuit is alive. Never remove or replace fuses in live circuits of more than 750 volts except by means of the suitable appliances provided.

D. Opening circuits at switches.—Special care should be exercised in opening circuits at meter connections unless the circuits have been first properly opened at switches.

E. Current-transformer secondaries.—Before working on an instrument or other device in a current-transformer secondary circuit, always bridge the device with jumpers, so that the circuit can not be opened at the device. Never open such a circuit at meter connections until it has been elsewhere bridged.

F. Special tools.—Use only hand tools suited to the work in hand and so reduce the danger of short-circuits.

G. Reporting defects.—Promptly report to your immediate superior any live meter case or any condition of a meter or its connections, of the interior wiring or of overhead lines, of your own or other utilities, which might endanger life and property.

432. Testing.

A. Application of rule.—All electrical testers, helpers, and others working about electrical tests shall study and strictly observe the following, in addition to all the general rules in 420 to 424. Owing to the diversified character of testing work, this study should usually extend also to the special rules in 433 to 435.

B. Authorization for work.—Do not work on or about equipment or lines without first receiving authorization from the person in charge.

NOTE.—If such equipment or lines are under control of a chief operator, this authorization must come from him. This will include the attaching of tags at the proper points and the observation of all rules for general operation in 421.

C. Checking of conditions.—Thoroughly familiarize yourself with all conditions surrounding equipment or lines to be tested before making any change in these conditions.

Do not make any change in equipment or lines unless you fully understand the effect of the change.

D. Foreman.—One properly qualified person shall be in immediate charge of all testing work, or all of the workmen shall be instructed as to the work they are to perform and the employee instructing them shall be considered in charge of the work.

E. Warnings and barriers.—Display danger signs and erect suitable guards about all equipment or lines under test when in places where traffic is frequent, if live or moving parts would otherwise be exposed.

When temporary wiring, belts, pulleys, or other temporary live or moving parts must be guarded, suitable portable or temporary guards and warning signs shall be used.

F. Requirement for two workmen.—No person should work alone in testing or experimental work on or about parts on which the voltage can exceed 750 volts, except in routine testing where the live parts are properly guarded.

G. Reporting defects.—Promptly report to your immediate superior any conditions of equipment or lines under test which may endanger life or property.

433. Overhead Lines.

A. Application of rule.—Linemen and assistants and groundmen, in construction, extension, removal, or repair work, shall study and strictly observe the following as well as all the general rules in 420 to 424 which apply to their work.

B. Testing structures before climbing.—Before climbing poles, ladders, scaffolds, or other elevated structures, first assure yourself that the pole, ladder, scaffold, tree, cross arm, messenger wire, cable car, or boatswain's chair, or other elevated support, is strong enough to safely sustain your weight.

NOTE.—Poles may be tested for decay near the ground line with a bar, screw driver, or other tool, and sounded for decay at the center by rapping with a heavy tool or block of wood.

When poles or cross arms are apparently unsafe because of decay or unbalanced tensions of wires on them, they should be properly braced or guyed before they are climbed.

C. Use of pole steps.—When poles are stepped, make use of such steps in climbing.

D. Unsafe supports.—Do not support yourself by pins, brackets, or conductors.

E. Spurs.—Spurs with gaffs worn short shall not be used. The gaffs on spurs shall be kept sharp, and spurs shall fit properly. Spurs shall not be worn on work for which they are not required, nor while men are traveling to or from work.

F. Care about live parts.

1. Do not go among any wires until you know their voltage.

2. Leaning over and crowding through unprotected wires should be avoided wherever possible.

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3. Place yourself so that you will not be liable to fall on wires should an accident occur.

4. Do not depend on the insulating covering of wires, and treat all lines as alive unless they have been properly killed (except communication lines known to be clear).

5. Avoid use of hand lines or measuring tapes containing metal strands.

6. In handling dangerous switches or fuses, do so only by means of suitable insulating handles, rods, or tongs.

G. When touching live parts.—When working on live equipment or wires never allow any portion of the body to come in contact with any live or grounded part other than that worked on.

While touching supply wires or equipment, avoid as far as possible touching ground wires, guy wires, span wires, metal pipes, metal poles, metal sheaths, communication wires or equipment, transformer cases, hangers, and other metal fixtures.

NOTE.—Communication wires are included principally because of their liability of being grounded. The other equipment and wires listed may become either alive or grounded.

While touching communication wires or equipment, metal sheaths, metal pipes, ground wires, or metal fixtures on poles, avoid as far as possible touching supply wires or equipment, guy or span wires.

H. Protecting traffic.—When working overhead, keep tools and materials not in use in proper receptacles; tools or materials should not be thrown to or from the man on the pole, but should be raised or lowered by means of a hand line, using proper receptacles where practicable.

Pole holes and obstructions along public highways and other frequented places shall be protected by watchmen or by suitable guards or danger signals so located as to be conspicuous to traffic.

When working overhead, or hoisting or lowering materials above places where frequent traffic occurs, a man should be stationed to warn passers-by.

NOTE.—Where traffic is light, warning signs or barriers may be used in lieu of watchmen. Where traffic is congested, it may be necessary to rope off the space.

I. Avoid falling objects.—Do not unnecessarily stand where you can be struck by materials dropped by men working overhead.

J. Stringing lines.—Never string wire near live lines except by means of suitable insulating hand lines or other appliances. Avoid bringing them in contact with the live lines. Regard them as live wires of the same voltage because of their liability to come in contact with the live lines.

Never change the strains on a pole by adding or removing wires until assured that the pole will stand the altered strains.

In stringing wires do not allow them to sag so as to endanger vehicles or pedestrians below, unless traffic is intercepted by watchmen or otherwise.

K. Reporting defects.—Report promptly to your immediate superior any dangerous conditions of your own or other utilities observed arising from defective insulators, pins, cross arms, abnormally sagging wires, etc.

434. Series Street Lamps.

A. Application of rule.—All series-lamp trimmers, hangers, and inspectors shall study and strictly observe the following, in addition to the general rules in 420 to 424 and the special rules under the sections for overhead and underground operation, respectively, in 433 and 436 which apply to their work.

B. Precautions on series circuits.—Series lamps and devices in series circuits should always be treated as alive unless disconnected by absolute cut-outs or protected by the grounding of the circuit.

C. Handling series lamps.—Trimmers, inspectors, or patrolmen shall wear suitable insulating gloves and stand on insulating stools, platforms, or tower wagons, or on dry, well-seasoned wood poles while touching series lamps or their cut-outs, when these are alive.

Where insulating stools, platforms, or tower wagons are used which provide sufficient insulation from ground for the voltages to be handled, the insulating gloves may be dispensed with.

D. Bridging series lamps.—Before working on lamps or other devices in live series circuits always bridge the device with jumpers such as series lamp cut-outs usually provide.

NOTE.—This will insure that the circuit will not be opened at the device and possibly be completed through your body or will not arc at the point of opening and burn you.

E. Testing series lamp circuits.—Series lamp circuits should not be tested at their full operating voltage unless it is impracticable to test otherwise. Tests should be made only in accordance with a time schedule, concerning which all persons whose safety may be affected are informed.

F. Periodically disconnected circuits.—If circuits, such as series lamp circuits, are not effectively grounded during the idle period, all rules for handling live parts shall be strictly observed.

G. Reporting defects.—Report promptly to your immediate superior any abnormally sagging wires, broken insulators, leaning poles, defective pole steps, broken globes or lamp supports, and other defects giving rise to a dangerous condition of your own or other utilities, or any indication of voltage on lines supposed to be dead.

435. Communication Circuits Used in Connection with Supply Lines.

A. Application of rule.—All men working on or near telephone and telegraph lines operated in connection with supply lines shall study and strictly observe the following in addition to all the general rules in section 42 and the special rules 433 and 436 which apply to their work. For rules governing the operation of commercial communication lines see sections 44 and 45.

B. Title of official in charge.—In those rules where the words "chief operator" are used the official in charge of safeguarding operation is to be understood.

C. Precautions before climbing poles.—Make a careful inspection to ascertain if possible whether there are any crosses with supply circuits before climbing poles or other structures to work on or about communication wires, especially where such poles or structures are occupied in common with, or located near, power circuits.

Apply mechanical tests as far as practicable to messenger wires before trusting the wires to carry your weight.

D. Approaching supply wires.—Avoid contact with all wires other than those you know to be communication wires, assuming such other wires always to be alive.

Do not approach any supply wire or supply equipment within the distances given in rule 422, B and C, unless you can comply with all the rules under that section as far as they apply.

NOTE.—Communication wires in trouble may be in contact with supply wires at some distant point, and should be treated with proper care.

E. Touching equipment.—While handling communication wires, metal sheaths, or communication equipment avoid touching guy or span wires and supply wires or equipment. Especially avoid standing on or touching transformer cases, hangers, or connections.

While touching open communication wires avoid contact also with grounded parts, such as sheaths and ground wires.

F. Stringing wires.—When stringing wires or cables over or under supply lines avoid any possibility of their coming in contact. Do not string them above live supply lines where it is practicable to avoid it.

Where liability of contact can not be entirely avoided, the lines being handled shall be treated as alive (unless they are effectively grounded), and the rules of 422, so far as they are applicable, shall be carefully observed.

G. Reporting dangerous conditions.—Promptly report to the proper official abnormally sagging wires, broken or defective insulators, pins, cross arms, defective poles, or any other dangerous conditions of your own or other utilities.

436. Underground Lines.

A. Application of rule.—All cable splicers and other workmen in underground construction or operation shall study and strictly observe the following, in addition to the general rules in 420 to 424, which apply to their work.

B. Guarding manholes, handholes, and street openings.—When removing manhole or handhole covers or making excavations, promptly protect the opening with a barrier, temporary cover, or other suitable guard, and see that danger signals or red lights are displayed in a location conspicuous to the traffic until permanent covers are in place or the excavations are filled.

C. Testing for gas.—Do not enter manholes until you have assured yourself that the manholes are free from dangerous gases, by testing with approved safety lamps, by ventilation, or by other adequate methods. (See rule 452, B, for testing for gas.)

D. Watchman on surface at manholes.—Do not enter a manhole unless a temporary cover is placed over the opening or a watchman is stationed at the surface. Where any gas is liable to be present always see that the watchman is stationed at the surface. Where any hazard is involved do not leave a manhole unwatched until all workmen are out.

E. Avoiding flames.—Do not smoke in manholes and avoid as far as practicable open flames or torches in or near manholes. Avoid sparks in handling live parts or cable sheaths, and avoid igniting the flux in soldering and wiping joints. In using hot paraffin see that it does not reach a temperature at which it will ignite. (See rule 452, D, for avoiding flames.)

F. Pulling cables.—When pulling in cables make sure that the gear can not slip so as to injure workmen. Avoid the danger of having the hands drawn into the tackle by the pulling line.

G. Unidentified cables.—If lines and cables are not properly identified by markings or positions, do not work upon them.

H. Testing and splicing live cables.—Always ascertain, if practicable, whether cables are alive, by testing with the test devices provided, before cutting into the cable sheaths. Live cable should be spliced only by men experienced in the work, and they should use extreme caution and suitable devices in so doing.

I. Reporting defects.—Promptly report to your immediate superior any dangerous condition of your own or other utilities, whether observed in underground or overhead construction. Particularly report insanitary conditions, gas, or missing cable tags in manholes, and abnormally sagging wires or broken supports in overhead construction.

437. Tunnel and Subway.

A. Application of rule.—Tunnel and subway electricians, operators, and others working on or about underground electrical equipment (not in stations, substations, or in underground conduit systems) shall study and strictly observe the following, in addition to the rules in 420, 421, 422, 430, and 436, so far as they apply to their work.

B. Dangerous locations.—The value of insulation (insulating covering) as protection from shock is reduced by the dampness usually present in these and similar locations. The restricted spaces often bring the worker closer to equipment and wires than in other kinds of electrical work, and the imperfect illumination also makes special care necessary to avoid contacts. The human body and all surrounding surfaces become more conducting where dampness exists, and electrical shocks are, therefore, more severe.

C. Live electrical parts.—Before handling any electrical equipment or wires make sure whether they are alive or dead.

NOTE.—It is not advisable to work on live equipment or wires when the current can be shut off without interrupting necessary operations.

D. Unauthorized work.—Never touch or disturb any electrical equipment or wires without being authorized.

E. Standing on ground.

1. Do not touch any electric wire, cable, or third rail, no matter how well it is insulated, while you are standing on the ground or on a grounded conducting surface, such as a pipe, track, or rail.

2. Do not touch the metal frame or case of a motor if it is ungrounded and you are in contact with ground or a grounded object.

NOTE.—Remember that the surfaces of damp ground and water are conducting. Insulation on a wire may look perfect, but it frequently will not prevent shock.

F. Carrying tools.—In carrying tools or metal implements in passageways containing electric wires, especially near exposed wires, never permit the tools or implements to touch them.

In particular, do not carry such objects on the shoulder when there are conductors overhead. Do not travel on that side of passageways where third rails or side trolley wires are exposed.

G. Handling and repairing live parts.

1. When necessary to handle or repair live trolley wires, third rails, cables, motors, or other electrical equipment, wear suitable insulating gloves or stand on the waterproof insulating mats or platforms provided, or obtain dry wood free from metal.

Do not rely entirely on gloves for protection. The gloves may have been punctured since they were previously tested.

2. Before handling or making use of any electrical cable, carefully examine it to make sure that its insulation is not injured.

H. Inspection of portable cables.—Portable cables should be inspected at least once daily during the period of their use.

I. Handling portable devices.—In handling portable motors or lamps, first make sure that the external metal frame is not alive by contact with or leakage from live parts within.

Have such portable devices inspected at least once daily during the period of their use.

J. Fuses and switches.—Never handle fuses nor close switches or circuit-breakers unless you are authorized to perform that special duty, and then use the insulating handles or rods provided.

Before closing switches, first make sure that you are not endangering other persons.

K. Injuring cables and wires.—Do not fire shots (blasting), handle tools, or perform other work in such a manner as to injure cables or wires in the vicinity. If in doubt, consult your superior.

L. Temporary wiring.—Never arrange the wiring of any temporary circuit for earth return, nor use bare conductors.

NOTE.—This particularly applies to the temporary portions of shot-firing circuits and to the leads of portable motors and lamps.

Never employ temporary circuits without seeing that there are installed at the junction with the permanent wiring suitable disconnecting switches or plug connectors, arranged to disconnect all conductors of the temporary circuit by a single operation.

For shot-firing circuits, their disconnectors should be left open until the shot is to be fired, and should preferably be arranged for locking in the open position.

M. General precautions.—Never get on or off locomotives or cars on the side where the trolley wire or third rail is located.

Do not place combustible or explosive materials near electric wires, trolley tracks, third rails, or motors. Do nothing that will cause sparking, or expose parts that may arc or spark during operation, if any explosive gases are present.

N. Reporting dangerous conditions.—Promptly report to your superior any dangerous or unusual conditions observed. In particular, report the presence of gas, broken insulators, bad insulation on wires, defective third-rail construction, live frames of motors, broken ground wires on motor frames, and sparking, arcing, or shocks noticed at any point. Report also any fallen, crossed, or abnormally sagging wires, whether electric wires or not. This includes trolley wires at switches and crossings and wires injured through falling roofs.

SEC. 44. COMMUNICATION SYSTEMS—RULES FOR EMPLOYERS

440. Distribution and Enforcement of Rules.

A. Distribution.—The employer shall furnish to each regular employee working on or about commercial telephone or telegraph equipment or lines, safety rules governing his conduct while so engaged, and shall take suitable means to secure the employee's compliance with the same.

B. Form.—The safety rules furnished to any employee may be in such form as the employer may determine is best suited to the needs of individual employees. They shall, however, include the principles set forth in the following rules, or at least such part thereof as is applicable to the work in which the employee is engaged, and shall not conflict with these rules.

C. Interpretation.—If a difference of opinion arises with regard to the meaning or application of these rules, or as to the means necessary to carry them out, the decision of the employer or his authorized agent shall be final, subject to an appeal (if taken) to the regulative body having jurisdiction.

441. Address List and Emergency Rules.

The rule books should contain or be accompanied by the following:

A. A list of names and addresses of those physicians and members of the organization who are to be called upon in emergencies.

B. A copy of rules for first aid, prone-pressure method of resuscitation, and fire extinguishment.

These should also be kept in conspicuous locations in central offices, on line wagons, and in other locations where the number of employees and nature of the work warrants.

442. Instructing Employees.

Employees regularly working on or about communication equipment or lines, if their duties render such training necessary, shall be thoroughly instructed in approved methods of first aid, the prone-pressure method of resuscitation and fire extinguishment, and if advisable, regularly drilled.

Groups of employees, such as commercial telephone operators, shall be thoroughly drilled to make prompt and orderly exit from buildings in case of fire.

443. Qualification of Employees.

The employer shall use every reasonable means and precaution to assure himself that each employee is mentally and physically qualified to perform his work in accordance with these rules, and that he is not addicted to the use of intoxicants and habit-forming drugs.

444. Protective Devices.

There shall be provided in conspicuous and suitable places in stations and on line wagons a sufficient supply of suitable protective, first-aid, and fire-extinguishing equipment to enable employees to meet the requirements of these rules. Such devices and equipment shall be inspected or tested to insure that they are kept in good order. The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case:

A. First-aid outfits.

B. Insulating wearing apparel, such as insulating gloves, boots, and shields.

C. Safety belts.

D. Fire-extinguishing apparatus.

SEC. 45. COMMUNICATION SYSTEMS—RULES FOR EMPLOYEES

450. General Precautions.

A. **Heeding warnings, warning others.**—Employees should cultivate the habit of being cautious, heed warning signs and signals, and always warn others when seen in danger near equipment and lines.

B. **Inexperienced employees.**—No employee shall do work for which he is not properly qualified on or about equipment or lines, except under the direct supervision of an experienced and properly qualified person.

C. **Electrical supply equipment or wires.**—Workmen whose duties do not require them to approach or handle electrical supply equipment and wires should keep away from such equipment or wires.

Electrical supply equipment and wires should always be considered as alive unless positively known to be dead.

D. **Safe supports and safety belts.**

1. *Safe supports.*—Employees should not support themselves on any portion of a tree, pole structure, lamp bracket or similar fixture on poles, scaffold, ladder, roof, skylight, or other elevated structure without first making sure that the supports are strong enough, reinforcing them if necessary. Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the supporting surfaces are smooth or vibrating.

Insecure makeshift substitutes for ladders should not be used. An employee should never trust his weight on thin wooden boxes, sinks, washbowls, window shelves, or chair backs.

A ladder should not be placed upon a box, barrel, or other movable or insecure object.

Care should be taken to see that chairs, rolling ladders, and similar equipment are in first-class condition before being used.

2. *Safety belts.*—Employees should not work in elevated positions unless secured from falling by a suitable safety belt or other adequate means (sometimes including suitably located pole steps). Before an employee trusts his weight to the belt, he should determine that the snaps or fastenings are properly engaged and that he is secured in his belt.

3. *Safety rope.*—Ropes used for supporting boatswains' chairs, platforms, or for other purposes on which the security of the employee depends shall be frequently inspected to assure that they are maintained in good condition.

E. Duties of foreman.

1. *Duties.*—Each foreman in charge of work shall see that the safety rules are observed by the employees under his direction. He shall make all necessary records; reporting to his superior when required. He shall permit only authorized persons to approach places where work is being done. He shall adopt such precautions as are within his power to prevent accidents, and prohibit the use of tools or devices which are defective or not suited to the work in hand.

2. *Qualified guides.*—The qualified person accompanying uninstructed workmen or visitors near electrical equipment or lines shall take precautions to provide suitable safeguards and see that the safety rules are observed.

F. Handling live parts.—No employee should touch, with bare hands, any exposed ungrounded live part of more than 150 volts to ground, unless he is insulated from other conducting surfaces, including the ground itself. When employees must touch, at the same time, two parts between which a considerable potential exists, insulating gloves or other protection shall be used.

G. Power circuits in central offices.—When making repairs on electric light or power circuits, the circuits shall, whenever possible, be made dead.

Where practicable, moving apparatus, as, for example, a fan, shall be stopped before working upon it.

None other than duly authorized persons shall be admitted to central-office transformer vaults or battery rooms.

Care shall be used while working on or near circuits of more than 150 volts to ground, particularly in alternating-current districts.

H. Handling fuses or brushes.—When working on the brushes of a machine in operation, employees shall use care not to break a circuit, the flashing of which may injure the eyes or burn the hands. If it is necessary to remove a brush from the holder, the machine shall be shut down.

When inspecting or changing fuses, care should be taken to prevent injury to the eyes. If it is necessary to handle the fuses, the circuit should be cut off, if possible.

I. Battery rooms.—Do not smoke or cause arcing in storage-battery room. The use of open flames should be avoided, especially while the cells are gassing, and should be permitted only in special cases under the direct supervision of an experienced person and after the room has been thoroughly ventilated.

451. Overhead Lines.

A. Precautions to be observed before climbing structures.—Before climbing poles, ladders, scaffolds, or other elevated structures first assure yourself that the pole, ladder, scaffold, tree, cross arm, messenger wire, cable car or boatswain's chair, or other elevated support is strong enough to safely sustain your weight.

On pole-replacement work no pole shall be climbed for the purpose of clearing it of all wires and cables without first guying or bracing the pole securely.

Where poles or cross arms are apparently unsafe because of decay or unequal strains of wire on them, they should be properly braced or guyed, if necessary, before they are climbed.

An uncoiled hand line, rope, or wire of any sort should not be fastened to the employee while climbing a pole, but where this must be done the employee should exercise due care to prevent the line from catching on obstructions.

In climbing poles careful watch should be kept for nails or other foreign attachments which might catch in the clothing and cause a fall.

B. Use of pole steps.—When poles are stepped make use of such steps in climbing, first making sure that the steps are firmly set in solid material before trusting your weight upon them. Pay particular attention, on icy poles, to each step.

Do not support yourself by pins, brackets, or conductors.

C. Spurs.—Spurs with gaffs worn short shall not be used. The gaffs on spurs shall be kept sharp and spurs shall fit properly. Spurs shall not be worn on work for which they are not required, nor while men are traveling to or from work.

D. Approaching supply lines.—Avoid contact with all wires other than those you know to be communication wires, assuming such other wires always to be alive. Communication wires in trouble may be in contact with supply lines at some distant point, and should be treated as live supply lines unless known to be free from any dangerous voltage.

Do not approach any supply line or supply equipment within the distances given in rule 422 under section 42, unless you comply with all the rules under that section.

E. Touching equipment.—While handling communication wires, metal sheaths, or communication equipment avoid touching trolley or arc-lamp span wires and supply lines or equipment. Especially avoid standing on or touching transformer cases, hangers, or connections.

F. Care about electrical supply lines.—Do not go among any wires until you know their voltage.

Leaning over and crowding through unprotected supply wires should be avoided wherever possible.

Place yourself so that you will not be liable to fall on supply wires should an accident occur.

Do not depend on the insulating covering wires, and treat all wires as alive unless they have been killed properly (except communication wires known to be clear).

Treat also as alive all wires (unless thoroughly grounded) which are being strung near supply wires; regard them as being of the same voltage as the supply wires.

Avoid use of hand lines or measuring tapes containing metal strands.

When necessary to work in the vicinity of supply wires, transformers, and similar equipment assure yourself before starting work that the position of the body is such that, should you momentarily forget yourself or fall, no portion of the body will come in contact with the foreign wires or equipment. Have the supply circuits killed where possible before approaching them.

Railway span wires, pull-offs, and trolley brackets shall be treated as if alive, even though equipped with strain or other insulators.

G. Stringing wires.—Never string wires near live circuits, except by means of suitable insulating hand lines or other appliances.

Avoid the use of single or paired wires as a substitute for a hand line.

Wires should not be strung above live circuits operating at more than 750 volts unless the wires being strung are

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effectively grounded or otherwise suitably protected, or in handling them all the precautions are observed as provided in rule 422 for work on parts at the voltage of the circuits concerned, and the spacings maintained.

Never change the strains on a pole by adding or removing wires until assured that the pole will stand the altered strains.

When wires are being pulled up on corner poles employees should stand in such a position that they can not be struck by the wire in case it slips.

Where it is necessary to remove communication wires below which are supply wires, power should be shut off of the supply wires where possible, and, if this is not practicable, rope cradles and suitable guards should be erected. Extraordinary care should be exercised to prevent the communication wires from sagging into the supply wires.

In stringing wires, cables, messengers, span wires, or guys do not allow them to sag so as to endanger vehicles or pedestrians below, unless traffic is intercepted by watchmen or otherwise. This may necessitate keeping a watchman at the coil or reel.

When stringing wires for long distances, precautions shall be taken to prevent the possibility of vehicles or pedestrians coming into contact with the wires at the intersecting streets or highway crossings.

H. Protecting traffic.—When working overhead, keep tools and materials not in use in proper receptacles; tools or materials should not be thrown to or from the man on the pole, but should be raised or lowered by means of a hand line, using a proper receptacle, if practicable. Also tools and loose materials should not be left at the top of poles, ladders, or other elevated structures.

Workmen shall not stand where they are liable to be struck by materials dropped by men working overhead.

Pole holes, open manholes, excavations, and obstructions along the public highway and other frequented places shall be protected by watchmen, barriers or suitable guards, warning signs, or danger signals so located as to be conspicuous to traffic.

When working overhead or hoisting or lowering materials above places where traffic occurs, a man should be stationed to warn passers-by.

Where traffic is light, warning signs may be used in lieu of watchmen. Where traffic is congested, it may be necessary to rope off the space.

I. Reporting dangerous conditions.—Report promptly to your immediate superior any observed dangerous conditions of your own or other utilities arising from defective insulators, pins, cross arms, abnormally sagging wires, etc.

Any imminently dangerous conditions shall be guarded until they can be made safe.

452. Underground Lines.

A. Guarding manholes, handholes, and street openings.—When removing manhole or handhole covers or making excavations, promptly protect the opening with a barrier, temporary cover, or other suitable guard, and see that danger signals or red lights are displayed in a location conspicuous to the traffic until permanent covers are in place or the excavations are filled.

B. Testing for gas.—Do not enter manholes until you have assured yourself that the manholes are free from dangerous gases, as indicated by approved safety lamps, by ventilation, or by other adequate methods.

When work is being carried on in manholes for any length of time where gas collects, suitable ventilation shall be provided, or tests with the safety device should be repeated at regular intervals to make certain that gas is not accumulating in the manhole in dangerous quantities.

C. Watchman on surface at manhole.—Where any hazard to the workmen is involved observe the following:

1. Do not enter a manhole unless a man is stationed at the surface.

2. Do not leave a manhole unwatched until all workmen are out.

D. Avoiding flames.—Do not smoke in manholes, and avoid as far as practicable open flames or torches in or near manholes.

If it is necessary to illuminate a manhole, electric lights only should be used. When doing this, it should be known that the leads, sockets, and connections are well insulated and in good condition in order to avoid the possibility of a spark. Special attention should be paid to the sparking of any motors used for ventilating purposes.

Avoid sparks in handling live parts or cable sheaths, and avoid igniting the flux in soldering and wiping joints. In using hot paraffin see that it does not reach a temperature at which it will ignite.

In central-office cable vaults, tests shall be made for the presence of gas before using exposed flames, and such flames shall not be used in vaults where gas collects.

E. Pulling cables.—When pulling cables, make sure that the gear can not slip so as to injure workmen. Avoid the danger of having the hands drawn into the tackle by the pulling line.

F. Reporting dangerous conditions.—Promptly report to your immediate superior any dangerous condition of your own or other utilities, whether observed in underground or overhead construction. Particularly report unsanitary conditions, gas, or missing cable tags in manholes and abnormally sagging wires or broken supports in overhead construction.

PART 5. SAFETY RULES FOR RADIO INSTALLATIONS

CONTENTS

SEC. 50. SCOPE

500. Scope.

The rules of part 5 apply to radio transmitting and receiving installations, including antennas, counterpoise wires, lead-in conductors, grounding conductors, grounding connections, protective devices, and batteries. The rules do not apply to antennas used for coupling carrier-current equipment to line conductors.

In case the installation is covered by more than one rule, the superior requirement shall apply.

SEC. 51. CLASSIFICATION OF RADIO STATIONS

510. Classification of Radio Stations.

For the purpose of these rules radio stations are classified as follows:

A. Receiving stations.

B. Transmitting stations.

1. *Low power.*—Transmitting stations to which the power supplied is less than 100 watts and where the voltage of the power supplied is less than 400 volts.

2. *Medium power.*—Transmitting stations not classified as low power or high power.

3. *High power.*—Transmitting stations to which the power supplied is greater than 1,000 watts or where the voltage of the power supplied is greater than 2,000 volts.

SEC. 52. ANTENNA AND COUNTERPOISE INSTALLATION

520. Application of Rules.

These rules apply to the following:

A. Outdoor antennas of all classes of receiving and transmitting stations. (There are no requirements for indoor antennas.)

B. Counterpoise wires.

521. General Requirements.

A. Counterpoise wires.—Counterpoise wires shall conform to the requirements for antennas similarly located.

B. Antennas of receiving and low-power transmitting stations.—Such antennas shall, in general, comply with the requirements for the construction of communication lines for public use in similar situations.

C. Antennas of medium and high power transmitting stations.—Such antennas shall, in general, comply with the requirements for the construction of supply lines in similar situations.

522. Locations to be Avoided.

The following situations should be avoided in erecting antennas and guy wires:

A. Attachments to supply or communication poles.

B. Crossings over railroad tracks or public highways.

C. Crossings over supply or communication conductors.

D. Crossings under supply or communication conductors.

E. Antenna conflicts with supply or communication conductors. (See definition of "Antenna conflict.")

523. Ordinary Construction of Antennas.

Antennas shall be constructed according to the requirements of rule 523 when they do not cross over railroad tracks, supply conductors, or communication conductors and do not conflict with supply or communication conductors.

A. Antenna conductors.

1. *Material.*

(*a*) RECEIVING ANTENNAS.

No requirements.

(*b*) TRANSMITTING ANTENNAS.

Antennas shall be of copper, bronze, copper-covered steel, or other metal which will not corrode excessively under the prevailing conditions.

2. *Size.*—Antenna conductor sizes shall be not less than given in Table 1.

Table 1.—Antenna Conductor Sizes—Ordinary Construction

Material	Receiving antennas		Transmitting antennas			
			Low power		Medium and high power	
	Size A.W.G.	Diameter	Size A.W.G.	Diameter	Size A.W.G.	Diameter
Copper:		*Inch*		*Inch*		*Inch*
Soft-drawn	14	0.064	14	0.064	7	0.144
Medium-drawn	14	.064	14	.064	8	.128
Hard-drawn	14	.064	14	.064	10	.102
Bronze or copper-covered steel	17	.045	14	.064	12	.081

3. *Strength.*

(*a*) ANTENNAS OF RECEIVING AND LOW-POWER TRANSMITTING STATIONS.

No requirements.

(*b*) ANTENNAS OF MEDIUM AND HIGH POWER TRANSMITTING STATIONS.

The strength of the antenna conductor shall be not less than that of No. 10 A. W. G. (diameter 0.102 inch) hard-drawn copper.

B. Antenna insulators.

1. *Antennas of receiving and low-power transmitting stations.*—No requirements.

2. *Antennas of medium and high power transmitting stations.*—Insulators shall be of noncombustible material and shall have a creepage distance of not less than 10 inches.

C. Antenna supports.

1. *Strength of supports.*—Supports shall be of such initial size as to carry the vertical load and where necessary shall be guyed or braced so as to withstand the transverse and longitudinal loads to which they may be subjected.

2. *Roof supports.*—Antenna supports erected on roofs shall be of rigid construction, and where necessary shall be arranged to distribute the load over the roof. Such supports shall be erected so that they are not dependent in any way on the antenna for stability.

3. *Chimneys.*—The attachment of antennas to chimneys should be avoided.

4. *Grounding metal supports on roofs.*—Metal poles or masts extending more than 10 feet above the supporting building shall be permanently and effectively grounded.

5. *Trees.*—Where a tree is used as an antenna support, sufficient sag (or other means) shall be provided to keep the tension in the antenna safely below the breaking strength when the tree sways in the wind.

D. Attaching antennas to supports.

1. *Strength of attachment.*—The means used for attaching the antenna to the support shall be such as to withstand a greater load than that which will break the conductor itself.

2. *Attachment on small poles.*—If the pole is not strong enough to support a person, some arrangement shall be provided to draw up the antenna from the ground.

E. Minimum clearance above ground.

1. *Spans 150 feet or less in length.*—Antenna conductors shall have clearances above ground as given in Table 2.

Table 2.—Minimum Antenna Clearances Above Ground

Location	Receiving and low-power antennas	Medium and high power antennas
	Feet	*Feet*
Above streets and other traveled roadways	18	28
Along road in rural districts	15	28
Above roadways to residence garages	10	----------
Above spaces or ways accessible only to pedestrians	10	----------

2. *Spans exceeding 150 feet in length.*—For such spans the above clearances shall be increased by 0.1 foot for each 10 feet in excess of 150 feet.

F. Minimum clearances below supply and communication conductors.—Antennas shall have the following clearances from conductors under which they cross:

Table 3.—Minimum Antenna Clearances Below Other Conductors

Crossing under—	Receiving and low-power antennas	Medium and high power antennas
	Feet	*Feet*
Communication conductors	2	10
Supply conductors, 0 to 750 volts	4	10
Supply conductors exceeding 750 volts	6	10

G. Clearances from combustible material.—Antennas of medium and high power transmitting stations shall be placed so that an air gap of at least 10 inches exists between the antenna and the nearest combustible material.

524. Special Construction of Antennas.

Antennas shall be specially constructed according to the following requirements when they cross over railroad tracks, supply conductors, or communication conductors, or are in conflict with supply or communication conductors.

A. Recommendation against locating antennas in situations where special construction is required.—It is strongly recommended that the installation of antennas in these special situations be avoided. If such locations are employed, it must be recognized that special hazards are introduced and that great care is necessary in the construction and maintenance of antennas to avoid contact with supply or communication conductors or to avoid the reduction of clearance over railroad tracks.

B. Construction of antennas crossing over or conflicting with service loops 0 to 150 volts to ground.—Antennas constructed in these situations shall conform to the requirements for the ordinary construction of antennas (rule 523) and, in addition, with the requirements set forth below for splices (rule 524, C, 2) and for minimum clearances above communication and supply line conductors (rule 524, C, 4).

C. Construction of antennas crossing over or conflicting with communication conductors or supply conductors 0 to 750 volts.

1. *Antenna conductor strength.*—The strength of the antenna conductor shall be not less than that of hard-drawn copper of the following sizes:

Span length	Size of hard-drawn copper	
	Size A. W. G.	Diameter
		Inch
0 to 150 feet	8	0.128
Exceeding 150 feet	6	.162

2. *Splices.*—Splices in antenna spans shall be made with a suitable twisted-sleeve connector which will provide a strong unsoldered joint.

3. *Antenna supports.*

(*a*) MATERIAL.

The poles for supporting antennas shall be of steel, concrete, or wood. Wood poles shall be free from observable defects that would decrease their strength or durability.

(*b*) SIZE.

Wood poles shall have a top diameter of not less than 6 inches.

(*c*) SETTING.

Poles shall be set to such a depth and in such a manner that any applied load will break the pole before the butt is pulled loose from its setting.

4. *Minimum clearances above communication and supply conductors, 0 to 750 volts.*—Antennas crossing over such conductors shall have the following clearances:

	Feet
Antennas of receiving and low-power transmitting stations	6
Antennas of medium and high power transmitting stations	10

D. Antennas crossing over railroads or crossing over or conflicting with supply lines exceeding 750 volts.

1. *Antennas of receiving and low-power transmitting stations.*—Such antennas shall conform to the requirements for communication lines for public use in similar situations as

far as grades of construction and clearances from all other wires and from ground are concerned. (See part 2.)

2. *Antennas of medium and high power transmitting stations.*—Such antennas shall conform to the requirements for supply lines in similar situations as far as grades of construction and clearances from all other wires and from ground are concerned. (See part 2.)

525. Guarding of Antennas.

Antennas for transmitting stations shall be installed or protected so as to be inaccessible to unauthorized persons.

SEC. 53. LEAD-IN CONDUCTORS

530. Application of Rules.

The requirements of this section apply to lead-in conductors of receiving stations and transmitting stations of low and medium power. Lead-in conductors of high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

531. Material.

Lead-in conductors shall be of copper, bronze, copper-covered steel, or other metal which will not corrode excessively under the prevailing conditions.

532. Size.

A. Receiving stations.—For receiving stations the size of lead-in conductor shall be not less than No. 14. A. W. G. (0.064 inch) if of copper, or less than No. 17 A. W. G. (0.045 inch) if of bronze or copper-covered steel.

B. Low and medium power transmitting stations.—For such transmitting stations the lead-in conductor shall be not less than No. 14 A. W. G. (0.064 inch).

533. Installation of Lead-in Conductor.

A. From antenna to first building attachment.—This section of the lead-in wire shall conform to the requirements for antennas similarly located.

B. From first building attachment to building entrance.—This section of the lead-in conductor shall be installed and maintained so that it can not swing closer to open supply conductors than the following distances:

	Feet
Supply lines 0 to 750 volts	2
Supply lines exceeding 750 volts	10

Exception.—The 2-foot clearance may be reduced if the lead-in conductor is separated from supply conductors by a continuous and firmly fixed nonconductor which will maintain permanent separation. This nonconductor shall be in addition to any insulating covering on the wires.

C. From building entrance to set.

1. *Receiving stations.*

(*a*) Lead-in conductors shall be securely fastened in a workmanlike manner.

(*b*) Clearance between lead-in conductor and any supply conductor not in conduit shall not be less than 2 inches.

Exception.—This 2-inch clearance does not apply if a firmly fixed nonconductor such as porcelain tube affords a permanent separation. This nonconductor shall be in addition to any insulating covering on the wires.

2. *Low and medium power transmitting stations.*

(*a*) Lead-in conductors shall be securely fastened to suitable insulators.

(*b*) Clearance between lead-in conductor and any supply wire shall be at least 5 inches.

(*c*) Lead-in conductors shall be installed and protected to prevent persons from readily coming into accidental contact with them.

SEC. 54. CONSTRUCTION AT BUILDING ENTRANCE

540. Application of Rules.

The requirements of this section apply to construction at receiving stations and transmitting stations of low and medium power. Construction at building entrances at high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

541. Entrance Bushing.

Lead-in conductors shall enter the building through a rigid, noncombustible, nonabsorptive, insulating tube or bushing, or through a drilled windowpane.

542. Creepage and Air-Gap Distance.

The entrance bushing or windowpane mentioned in rule 541 above shall afford the following creepage and air-gap distance from extraneous bodies:

Receiving stations	No requirement.
Low and medium power transmitting stations using damped waves	5 inches.
Low and medium power transmitting stations using undamped waves	3 inches.

543. Mechanical Protection of Bushings.

Entrance bushings of porcelain or other fragile material at transmitting stations shall be protected where exposed to mechanical injury.

SEC. 55. PROTECTIVE AND OPERATING GROUNDING CONDUCTORS

550. Application of Rules.

The requirements of this section apply to grounding conductors of receiving stations and transmitting stations of low and medium power. Grounding conductors of high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

551. General.

The protective grounding conductor may be used also as the operating grounding conductor.

552. Material and Size.

A. Receiving stations.

1. *Material.*—No requirements.

2. *Size.*—

(*a*) OPERATING GROUNDING CONDUCTOR.

No requirements.

(*b*) PROTECTIVE GROUNDING CONDUCTOR.

This conductor shall not be smaller than the lead-in conductor.

B. Transmitting stations.—The operating and grounding conductors shall have strength and conductance per unit length not less than No. 14 A. W. G. (0.064 inch) hard-drawn copper.

553. Installation of Grounding Conductors.

A. Method of running.

1. Grounding conductors shall be run in as straight a line as possible from the set or the protective device to a good permanent ground.

2. Grounding conductors may be run either inside or outside of the building.

Recommendation.—It is recommended that the protective grounding wire for low and medium power transmitting stations be run outside of the building.

B. Mechanical protection.—Grounding conductors shall be guarded where exposed to mechanical injury.

C. Insulation.—Grounding conductors may be of insulated or bare wire and need not be run on insulating supports.

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SEC. 56. ,GROUND CONNECTIONS

560. Application of Rules.

The requirements of this section apply to ground connections for all classes of transmitting stations and to protective ground connections of receiving stations.

561. General.

Grounding shall be done in accordance with the following methods. (See section 9 for complete rules for grounding)

562. Gas Pipe Not to be Used.

Gas pipe should not be used for grounding purposes.

563. Water-pipe Grounds.

The ground connections shall be made to a cold-water pipe where such pipe is available and is in service and connected to the street mains. An outlet pipe from a water tank fed by a street main or a well may be used, provided such outlet pipe is adequately bonded to the inlet pipe connected to the street water main or well.

564. Attachment to Pipes.

Grounding conductors shall be attached to pipes by means of suitable ground clamps. The entire surface of the pipe to be covered by the clamp shall be thoroughly cleaned.

565. Driven or Buried Grounds.

If cold-water pipes are not available, ground connections may be made to a galvanized-iron pipe or to a rod driven into permanently damp earth or to a metal plate or other body of metal buried similarly.

566. Attachment to Ground Rod or Plate.

The grounding conductor shall be attached to the rod, buried plate, or other body of metal so as to give reliable connection both mechanically and electrically. This connection shall be made so that it will not fail through corrosion, even when the joint is buried in the earth.

SEC. 57. PROTECTIVE DEVICES

570. Application of Rules.

The requirements of this section apply to protective devices for receiving stations and transmitting stations of low and medium power. Protective devices for high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

571. Lightning Arrester.

A. Where required.—Each lead-in conductor of a receiving station shall be provided with a lightning arrester, whether or not an antenna grounding switch is used.

B. Operating voltage.—The lightning arrester shall be such as to operate at a potential of 500 volts or less.

C. Location.—The arrester may be located outside the building as near as practicable to the point of entrance, or inside the building between the point of entrance and the receiving set and convenient to a ground. The arrester shall not be placed in the immediate vicinity of easily ignitible material or in a location exposed to dust, inflammable gases, or flyings of combustible materials.

572. Antenna Grounding Switch.

A. Where required.—An antenna grounding switch shall be used at low and medium power transmitting stations. An antenna grounding switch is not required at receiving stations, but may be used in addition to the lightning arrester.

B. Type of switch.

1. *Receiving stations.*—The switch should be of the single-pole double-throw type.

2. *Low and medium power transmitting stations.*—The switch shall be of the double-throw type and shall meet the following requirements:

Minimum break distance	4 inches.
Minimum cross-section of switch blade	⅛ inch x ½ inch.

Switch base: Nonabsorptive insulating material.

C. Location.—The switch may be located either outside or inside the building. The switch should be placed in the most direct line between the lead-in conductor and the point where the grounding connection is made.

D. Clearance for live switch parts.—The switch shall be mounted so that its current-carrying parts will clear the building wall or conductors not connected to the switch by the following distances:

Switches for receiving stations: No clearance required.

Switches for low and medium power transmitting stations:

Damped-wave sets	5 inches.
Undamped-wave sets	3 inches.

E. Method of connection.

1. *Receiving stations.*—The switch shall be wired so that the antenna lead-in conductor can be disconnected from the set and connected to the grounding conductor. When in the grounding position the switch shall short-circuit the lightning arrester.

2. *Low and medium power transmitting stations.*—No requirements.

F. Operation of switch.

1. *Receiving stations.*—No requirements.

2. *Low and medium power transmitting stations.*—Antenna and counterpoise lead-in conductors of low and medium power transmitting stations shall be connected to the grounding conductor whenever the station is not in use.

573. Protection Against Kick-back.

A. Where required.— Protection should be provided at low and medium power transmitting stations where necessary to protect the supply system against high-potential surges and "kick-backs."

Any of the following methods may be used:

1. Two condensers, usually of 0.1 to 0.5 microfarad capacity and capable of withstanding five times the normal voltage to which they are subjected, placed in series with one another across the supply line with mid-point between condensers grounded. Across (in parallel with) each of these condensers shall be connected a shunting fixed spark gap capable of not more than one thirty-second inch separation.

2. Two vacuum-tube-type protectors in series with one another across the line with the mid-point grounded (if the line voltage does not exceed 110 volts).

3. Electrolytic lightning arresters, such as the aluminum-cell type.

C. Location.—Apparatus for protection against "kick-back" should be installed across the supply conductors as near as possible to each radio transformer, rotary spark gap, motor, and generator (in motor-generator sets), or other auxiliary apparatus.

SEC. 58. CONNECTION TO POWER SUPPLY LINES

580. Connection to Power Supply Lines.

Devices used in connection with power supply lines and methods of wiring shall be in accordance with the rules covering permanent or portable fixtures, devices, and appliances. (See sec. 37.)

SEC. 59. BATTERIES

590. Application of Rules.

The requirements of this section apply to batteries for receiving stations and transmitting stations of low and medium power. Battery installations for high-power transmitting stations shall meet such requirements of part 1, "Supply stations," as apply.

591. Care in Handling.

Care shall be used in handling batteries in order to avoid contacts with terminals having a high enough difference of potential to cause shock.

592. Storage Battery.

A. Wiring.—The wiring of storage batteries used with radio receiving equipment shall be subject to the rules covering the wiring of permanent or portable fixtures, devices, and appliances. (See sec. 37.)

B. Ventilation.—Storage batteries shall be located where there is adequate ventilation.

C. Precautions.

1. Open flames shall be kept away from storage batteries.

2. Storage batteries should be placed on trays or mats of lead, rubber, or other material which will not be affected by the electrolyte.

D. Large battery installations.—Installations of nonportable storage batteries of more than 50-kilowatt-hour capacity at the 8-hour rate of discharge, if used for radio, shall comply with section 13 and rule 353.

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[References are to rule numbers. The following abbrevations are used: Def. for definitions; app. for appendix; sec. for section]

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