B. S. HANDBOOK SER. No. 7

DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

George K. Burgess, Director

SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRIC UTILIZATION EQUIPMENT

HANDBOOK OF THE BUREAU OF STANDARDS, No. 7

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

HANDBOOK SERIES OF THE BUREAU OF STANDARDS, No. 7

SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRIC UTILIZATION EQUIPMENT

CONSISTING OF PART 3 AND THE GROUNDING RULES OF THE FOURTH EDITION OF THE NATIONAL ELECTRICAL SAFETY CODE

March 12, 1926

PRICE 15 CENTS

Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1926

PREFACE

Previous editions of the National Electrical Safety Code have been published in complete form. There has been some demand, however, for smaller handbooks containing a single part of the code, and in response to this demand the fourth edition is being issued not only as a whole but also as separate publications dealing with the several subjects covered.

This volume contains part 3 dealing with utilization equipment, along with the grounding rules contained in section 9.

The present edition of these rules is a result of a revision which has been carried out according to the procedure of the American Engineering Standards Committee and the revised rules have had the approval of the sectional committee organized according to those rules of procedure. A discussion of these rules will be found in the revised edition of Handbook Series No. 4.

Two sizes of type have been used in the text; the larger containing the rules proper, whereas explanatory notes, etc., are in smaller type.

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

GEORGE K. BURGESS,
Director.

CONTENTS

SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRIC UTILIZATION EQUIPMENT

COMPRISING PART 3 AND THE GROUNDING RULES OF THE FOURTH EDITION, NATIONAL ELECTRICAL SAFETY CODE

DEFINITIONS

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.

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.

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

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

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.

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

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.

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.

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.

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 communication 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.

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.

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

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.

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

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.

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.

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.

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.

Insulated means separated from other conducting surfaces by a dielectric substance or air space permanently

69665°—26——2

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 understood 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.

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

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

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

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

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

Manual means capable of being operated by personal intervention.

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.

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

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.

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

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."

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

Switch 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.

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.

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

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.

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

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.

SEC. 9. RULES COVERING METHODS OF PROTECTIVE GROUNDING OF CIRCUITS AND UTILIZATION EQUIPMENT

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 or 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 a 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

69665°—26——3

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 drainpipes, 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.

69665°—26——4

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 3-wire (not delta 3-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.

69665°—26——5

(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 panelboard 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) **Panelboards.**—Switches shall be so placed that each panelboard 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 panelboards 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 arrangments 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 for 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 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 persons 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 in-

closing 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.

(l) **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 PANELBOARDS

330. Accessibility and Convenient Attendance

(a) **Control arrangement.**—Switchboards and panelboards 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 panelboards 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 panelboard 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 panelboard 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 panelboards 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. Panelboards

(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 panelboards employing plug fuses without switches in main or branch circuits.

(b) **Material.**—Panelboard bases shall be made of nonabsorptive, noncombustible insulating material.

(c) **Marking.**—Panelboards 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 panelboards are installed so as to be exposed to excessive moisture they shall be inclosed in weatherproof cabinets.

(e) **Hazardous locations.**—Panelboards shall not be installed where hazardous conditions exist due to the presence of inflammable gas or inflammable dust or flyings.

(f) **Residences.**—Panelboards 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 flying 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 trav-

eling 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 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.

○