

**U. S. DEPARTMENT OF COMMERCE**  
**NATIONAL BUREAU OF STANDARDS**

**SAFETY RULES FOR THE  
INSTALLATION AND MAINTENANCE OF  
ELECTRIC UTILIZATION EQUIPMENT**

**Comprising Part 3 and the Grounding Rules  
of the Fifth Edition, National  
Electrical Safety Code**

**NATIONAL BUREAU OF STANDARDS HANDBOOK H33**  
**(Supersedes H7)**



U. S. DEPARTMENT OF COMMERCE

HARRY L. HOPKINS, Secretary

NATIONAL BUREAU OF STANDARDS

LYMAN J. BRIGGS, Director

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National Bureau of Standards Handbook H33

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U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS  
SAFETY CODE FOR  
PREFACE

This handbook contains part 3 of the National Electrical Safety Code dealing with utilization equipment. The grounding rules contained in section 9 are also reproduced here. This handbook supersedes Handbook No. 7.

The present edition of these rules is the result of a revision which has been carried out according to the procedure of the American Standards Association, and the revised text has had the approval of a sectional committee organized in conformity with those rules of procedure.

A discussion of these rules will be found in the revised edition of the handbook entitled "Discussion of the National Electrical Safety Code."

Criticism of the rules and suggestions for their improvement are invited, especially from those who have experience in their practical application. In future editions every effort will be made to perfect the rules still further, both in the development of detail and in the modification of any requirements which it is found can be improved.

LYMAN J. BRIGGS, *Director.*

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# SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRIC UTILIZATION EQUIPMENT

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

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## 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.

**Appliance** means current-consuming equipment, fixed or portable; for example, heating, cooking, and small motor-operated equipment.

**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.

**Current-carrying part** means a conducting 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.

**Device** means a unit of an electrical wiring system which is intended to carry but not consume electric energy.

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

*Note:* 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.

**Effectively grounded** means permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient current-carrying capacity to prevent the building up of voltages which may result in undue hazard to connected equipment or to persons.

**Electric supply equipment** means equipment which produces, modifies, regulates, controls, or safeguards a supply of electric 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 electric supply equipment is located and the interior of which is accessible, as a rule, only to properly qualified persons.

*Note:* This includes generating stations and substations and generator, storage battery, and transformer rooms, but excludes manholes and isolated transformer vaults on private premises.

**Equipment** means a general term including fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electric installation.

**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.

**Externally operable** means capable of being operated without exposing the operator to contact with live parts.

*Note:* This term is applied to equipment, such as a switch, that is enclosed in a case or cabinet.

**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 of conductors in which at least one conductor or point (usually the middle wire, or neutral point of transformer or generator windings) is intentionally grounded, either solidly or through a current-limiting device.

**Grounding conductor** means a conductor which is used to connect the equipment or the wiring system with a grounding electrode or electrodes.

**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 offering a high resistance to the passage of current and to disruptive discharge through the substance or space.

*Note:* When any object is said to be insulated, it is understood to be insulated in 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.

**Lightning arrester** means a device which has the property of reducing the voltage of a surge applied to its terminals, is capable of interrupting follow current if present, and restores itself to its original operating conditions.

**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, or a group of panel units designed for assembly in the form of a single panel; including buses and with or without switches and/or automatic over-current protective devices for the control of light, heat, or power circuits of small individual as well as aggregate capacity; designed to be placed in a cabinet or cut-out box placed in or against a wall or partition, and accessible only from the front. (See switchboard.)

**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 conductors and equipment for delivering electric energy from the secondary distribution or street main, or other distribution feeder, or from the transformer, to the wiring system of the 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 inclosure either above or below ground with fire-resistant walls, ceiling, and floor, in which transformers and related equipment are installed, and which is not continuously attended during operation.

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

**Voltage** (of a circuit) means the highest effective voltage between any two conductors of the circuit concerned.

**Exception:** Voltage of a grounded multiwire circuit, not exceeding 750 volts between any two conductors, means the highest effective voltage between any wire of the circuit and that point or conductor of the circuit which is grounded.

If 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 effectively grounded in which case its voltage is not determined by the circuit of higher voltage. Direct connection implies electrical connection as distinguished from connection merely through electromagnetic or electrostatic induction.

**Voltage to ground of a grounded circuit** means the highest effective voltage between any conductor of the circuit and that point or conductor of the circuit which is grounded. For ungrounded circuits it means the highest effective voltage between any two conductors of the circuit concerned.

**Voltage to ground of a conductor of a grounded circuit** means the highest effective voltage between such conductor and that point or conductor of the circuit which is grounded. For ungrounded circuits it means the highest effective voltage between such conductor and any other conductor of the circuit concerned.

## **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 raceways when the grounding is intended to be a permanent and effective protective measure.

They do not apply to the grounded return of electric railways, nor to the grounding of lightning protection wires which are independent of electric circuits or equipment. These rules do not require that grounding shall be done, but cover the methods for protective grounding. The rules requiring grounding, in accordance with the methods specified below, are included under the various parts of this code.

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

### **91. APPLICATION OF THE RULES.**

#### **A. Waiving Rules.**

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

#### **B. Application.**

The intent of the rules will be realized (1) by applying the rules in full to all new installations, reconstructions, and extensions, except where any rule is shown to be impracticable for special reasons or where the advantage of uniformity with existing



**91. B. Application—Continued.**

construction is greater than the advantage of construction in compliance with the rules, provided 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 for specified limited periods of time 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.**

Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services and not elsewhere on interior wiring. In three-wire direct-current systems the ground connections shall be made on the neutral.

**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

**92. B. Alternating-Current Distribution Systems—Contd.**  
ground wire, the resistance and current-carrying requirements of these rules.

If 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 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.

The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective functions, are not to be considered as objectionable.

If an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds, (1) one or more of such grounds shall be abandoned, or (2) their location shall be changed,

**92. C. Current in Grounding Conductor—Continued**

or (3) the continuity of the conductor between the grounding connections shall be suitably interrupted, or (4) other means satisfactory to the administrative authority shall be taken to limit the current.

**D. Equipment and Wire Raceways.**

Metal boxes, cabinets and fittings, or non-current-carrying metal parts of other fixed equipment, if metallically connected to grounded cable armor or metal raceway, are considered to be grounded by such connection. Where the metal enclosure of a wiring system is used as part of the protective grounding, the electrical continuity of the enclosure shall be assured.

For conduit, armored cable, or metal raceways the ground connection shall be as near as practicable to the point where the conductors in the raceway 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

**93. A. Material and Continuity—Continued.**

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 grounding conductor shall conform to the following:

**1. FOR DIRECT-CURRENT CIRCUITS.**

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

**2. FOR ALTERNATING-CURRENT CIRCUITS.**

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

**3. FOR INSTRUMENT TRANSFORMERS.**

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

**4. FOR LIGHTNING ARRESTERS.**

The grounding conductor or conductors shall have a current capacity sufficient to insure continuity and continued effectiveness of the ground connection under conditions of excess current caused by or following discharge of the arrester. No individual grounding conductor shall have less conductance than No. 6 (0.162-inch) copper wire.



### 93. B. Size and Capacity—Continued.

#### 5. FOR RACEWAYS AND EQUIPMENT.

The current-carrying capacity of grounding conductors for equipment, raceways, cable armor, and other metal enclosures for wires, when provided with overcurrent protection, shall be sufficient to provide adequate draining of fault current during the time required for the protective device to operate. Where connected to artificial electrodes, the grounding conductor need not be larger than No. 6 copper wire or its equivalent. If no fuse or automatic circuit-breaker is provided, the capacity of the grounding conductor shall be determined by the design and operating conditions of the circuit, but shall not be smaller than No. 8.

#### 6. FOR PORTABLE AND PENDENT EQUIPMENT.

For grounding portable or pendent equipment, the conductors to which are protected by fuses or circuit-breakers rated or set at not exceeding 15 amperes, No. 18 copper wire may be used. For grounding portable or pendent equipment protected at more than 15 amperes, see preceding paragraph.

### 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

93. C. Mechanical Protection and Guarding Against Contact.—Continued.

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.

*Exception 1:* A grounding conductor for a circuit having at least two ground connections, where such conductor is entirely outside buildings and has strength and current capacity not less than No. 8 (0.1285-inch) copper wire.

*Exception 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.

## 93. Grounding Conductor—Continued.

**E. Common Grounding Conductor for Circuits, Metal Raceways, and Equipment.**

The grounding conductor of an interior wiring system may be used also as the grounding conductor for equipment, conduit, and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment, provided such grounding conductor meets the current-carrying-capacity requirements for service raceways, as specified in paragraph B above; and provided further, that the secondary distribution circuit supplying the interior wiring system has at least one additional ground at the transformer or elsewhere.

## 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 be avoided for circuit grounding wherever practicable.

*Note:* The protective grounding of electric 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.



94. *Ground Connections—Continued.***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, 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 noncurrent-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.**

If 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

## 94. C. Artificial Grounds—Continued.

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.

The point of attachment of a grounding conductor to a water-piping system shall be on the street side of the water meter, or on a cold-water pipe of adequate current-carrying capacity, as near as practicable to the water-service entrance to the building or near the equipment to be grounded, and shall be accessible except by special permission. If the point of attachment is not on the street side of the water meter, the water-piping system shall be made electrically continuous by bonding together all parts between the attachment and the pipe entrance which

**95. A. Piping—Continued.**

are liable to become disconnected, as at meters and service unions. If water meters are located outside buildings or in concrete pits within buildings where piping connections are embedded in concrete flooring, the ground connections may be made on the building side of the meters.

Gas-piping systems within buildings shall not be used for purposes of this rule where water pipes are readily available. Gas piping may serve as the grounding electrode for fixtures located at a considerable distance from water piping. Where gas piping is so used it shall be bonded to the water-piping system at the point of entrance of water piping. (See rule 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 practicable.

*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.

## 95. C. Contact Surfaces—Continued.

Conduits, other metal raceways, and the armor of cables 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 lock nuts and bushings, these conduits should be bonded together.

## D. Electrodes for Artificial Grounds.

Where artificial grounds are used, the electrodes shall, as far as practicable, be embedded below permanent moisture level.

Buried-plate electrodes shall present not less than 2 square feet of surface to exterior soil. Electrodes of plate copper shall be at least 0.06 inch in thickness. Electrodes of iron or steel plates shall be at least  $\frac{1}{4}$  inch in thickness.

Electrodes of iron or steel pipe shall be galvanized and not less than  $\frac{1}{2}$  inch (nominal size). Electrodes of rods of steel or iron shall be at least  $\frac{3}{4}$  inch minimum cross-sectional dimension. Approved rods of nonferrous materials or their approved equivalent used for electrodes shall be not less than  $\frac{1}{2}$  inch in diameter. Driven electrodes of pipes or rods, if of less than standard commercial length, shall preferably be of one piece, and, except where rock bottom is encountered, shall be driven to a depth of at least 8 feet regardless of size or number of electrodes used. Such pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel, or other poorly conducting materials.

Pole-grounding electrodes may be wire attached to the pole previous to the setting of the pole. The wire shall have a continuous length below ground level of not less than 12 feet, shall extend to the bottom of the pole, and shall be not smaller than No. 6 (0.162 inch).



**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 electrode, artificial-ground resistance as low as 25 ohms, this requirement shall be waived, and two or more electrodes, at least 6 feet apart, 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 is used.

**97. SEPARATE GROUNDING CONDUCTORS AND GROUNDS.****A. Grounding Conductors.**

Grounding conductors from equipment and circuits of each of the following classes, if 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, except as provided in paragraph C and in rule 283, B.

**97. A. Grounding Conductors—Continued.**

1. Lightning arresters.
2. Secondaries connected to low-voltage lighting or power circuits, except that if a secondary distribution system has multiple grounds, utilization equipment and wire enclosures may use the same grounding conductor.
3. Secondaries of current and potential instrument transformers having primary voltages of more than 750 volts, and cases of instruments on these secondaries.
4. Frames of direct-current railway equipment and of equipment operating in excess of 750 volts.
5. Frames of utilization equipment or wire raceways other than covered by item 4, except as provided in item 2.
6. Lightning rods.

**B. Electrodes.**

Where individual artificial grounds are used, separate grounding electrodes as well as separate grounding conductors shall be used. This does not prohibit the bonding together of these separate electrodes near the ground level.

**C. Interconnection of Primary Arrester and Secondary Neutral.****1. SOLID INTERCONNECTION.**

The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected with the grounded conductor of such secondary distribution system, provided that in addition to the direct grounding connection at the arrester either:

- (a) The secondary has elsewhere a grounding connection to a continuous metallic underground water piping system (except that in urban water-pipe areas where there are four water-pipe grounds

## 97. C. 1. Solid Interconnection—Continued.

in each mile of secondary and not less than four on any individual secondary, the direct grounding connection at the arrester may be omitted); or

- (b) The secondary neutral (which may or may not be common with the primary neutral) has at least four ground connections in each mile of line in addition to a ground connection at each individual service, or
- (c) Permission is obtained from the administrative authority for any other condition.

## 2. INTERCONNECTION THROUGH SPARK GAP.

Where the secondary is not grounded as in item 1, interconnection, if made, shall be through a spark gap having a 60-cycle breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 15 kilovolts, and there shall be at least one other ground on the grounded conductor of the secondary that is at least 20 feet distant from the lightning-arrester grounding electrode.



# THE HISTORY OF THE

of the island of St. George's, in the  
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in 1493, to the present time.

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History of the War between Great  
Britain and France, from the Year  
1756 to 1763, and of the Peace  
which followed.

## 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 between conductors 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 is 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 Equipment.**

Equipment which has 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

**302. A. Approved Equipment—Continued.**

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 equipment 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 National 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 other related safety codes approved by the American Standards Association, and particularly to the National Electrical Code ASA. C1.

*Note:* Copies of these codes can be obtained from the American Standards Association, 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.

## 304. Grounding—Continued.

**B. Circuits Required to be Grounded.**

All circuits included in rule 300, A shall be effectively grounded in accordance with the rules of section 9, except that the following are not required to be grounded:

*Exception 1:* Circuits on two-wire direct-current systems, provided the system is equipped with a ground detector.

*Exception 2:* Delta-connected three-phase circuits; except that such circuits when partly used for lighting shall be so arranged and grounded, that the lighting circuits will have the lowest practicable voltage to ground.

*Exception 3:* Circuits of more than 150 volts to ground.

*Note:* It is recommended that such circuits be grounded if the voltage to ground of any conductor of the circuit will not exceed 300 volts after grounding.

*Exception 4:* Electric furnace circuits. (See rule 351.)

*Exception 5:* Electric crane circuits operating over combustible fibers.

*Exception 6:* Circuits of less than 50 volts between conductors unless run overhead between buildings, or supplied by transformers operating on circuits of more than 150 volts to ground, or by transformers operating on ungrounded circuits.

**C. Grounding Non current-Carrying Metal Parts.**

Conductor armor, conductor raceways, and all equipment supplied directly by metal-incased wiring shall be grounded.

Exposed noncurrent-carrying metal parts of other fixed electric utilization equipment (such as frames of motors, cranes, cars, and switchboards, and inclosures of switches and transformers) shall be grounded under any one of the following conditions: (See section 9 for method of grounding, and rule 371 for portable appliances.)



### 304. C. Grounding Noncurrent carrying Metal Parts—Continued.

1. If operated at more than 150 volts to ground, regardless of location.
2. If located where exposed grounded surfaces, such as metal frames of other machines, plumbing fixtures, conducting floors or walls, exist within reach of persons while 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. If located where explosives, inflammable gas, or inflammable flyings normally exist in dangerous quantities, regardless of voltage.

*Exception 1:* 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 this rule and may be left ungrounded.

*Exception 2:* 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 cannot readily touch the metal frames in question without standing on such mats, floors, or platforms. (See also rules 329, H, 1 (d) and 344 for further exception.)

### 304. C. Grounding Noncurrent-Carrying Metal Parts—Continued.

*Exception 3:* No ground connection need be made to metal inclosures housing interior wiring conductors, provided such inclosures do not exceed 25 feet in length, are insulated from grounded piping or other grounded surfaces and are out of reach from grounded surfaces or guarded against contact by persons.

*Exception 4:* No ground connection need be made to metal pipe used for the mechanical protection of interior wiring conductors, provided each of the conductors contained are encased in a continuous nonconducting flexible tubing.

### 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



**305. D. Elevation of Equipment—Continued.**

by the horizontal clearances of B and may be used in lieu thereof.

**306. GUARDING OR ISOLATING LIVE PARTS.****A. Inclosure or Elevation.**

Except as elsewhere required or permitted by this code, all bare, ungrounded live parts of electric utilization equipment, such as bus bars, conductors, and terminals, operating at more than 50 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 flameproofing 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 cannot 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

### 306. B. Exception Where Mats and Platforms are Used—Continued.

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 accumulation of conducting dust, flyings, or chips, mats should present surfaces minimizing the hazards from these sources.

### 307. HAZARDOUS LOCATIONS.

#### A. Where 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 Wet Places.

External parts of lighting fixtures and all other electric equipment when within eight feet of the floor in wet locations shall be constructed of nonabsorptive insulating materials or, if of metal, shall be grounded as required by rule 304, C.

### 308. PROTECTION BY DISCONNECTION.

Electric utilization equipment which will require maintenance work upon it shall have approved means of disconnecting it from all ungrounded conductors of its supply circuit.

*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.

**308. Protection by Disconnection—Continued.**

1. If the control apparatus opens all the main leads to the motor, and the pilot circuits are fused, a disconnecter only is required for connected loads in excess of 50 horsepower.
2. If the control apparatus does not open all of the main leads to the motor, a circuit switch or other approved disconnecting means shall be used.

*Note:* By main leads to the motor is meant: *dc motors*—all armature circuits (not including shunt-field circuits); *ac motors*—all primary leads (not including the secondary leads of a slip-ring motor or the field circuit of a synchronous motor).

3. The disconnecting means shall make all circuits of the controller and motor dead.
4. If the disconnecting means is equipped for locking in the open position it need not be in sight of the motor.
5. If 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

**310. A. Fuses and Circuit-Breakers—Continued.**

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 and Neutral Conductors.**

No fuse or other automatic circuit-breaking device shall be placed in any conductor which is required to be grounded, nor in the neutral conductor of a three-wire system, except as follows:

**1. SIMULTANEOUS OPENING.**

If the automatic circuit-breaking device simultaneously opens all conductors of the circuit.

**2. CONDUCTORS OF BRANCH CIRCUITS.**

In locations where the conditions of grounding, or the likelihood of reversal of connection warrants, the administrative authority may require, on systems having a grounded neutral or having one side grounded, that the conductors of two-wire branch circuits shall have a fuse or other automatic circuit-breaking device in each conductor.

**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.**

In the case of service switches, if the switch does not interrupt the grounded conductor, other means shall be provided in the service cabinet or on the switchboard for disconnecting the grounded conductor from the interior wiring.

**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 cannot be opened without opening both outside wires.**



**310. C. Switches—Continued.**

4. Electric meters and control circuits of time switches may be connected on the supply side of the service switch and fuses or circuit-breaker on alternating-current supply not exceeding 300 volts between conductors, provided no wiring or live parts are exposed and the connections are inaccessible to unauthorized persons.

**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 grounded neutral conductor of multiwire alternating-current circuits, the grounded neutral conductor of three-wire circuits and the grounded 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 identified if run in conduits. For rubber-covered wires (not including flexible cord or fixture

## 312. A. Conductors—Continued.

wire) of size No. 6 (0.162 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 location relative to others, in order to preserve the continuity of the marking.

If the system to which the circuit is connected is a grounded system, the identified conductor shall be connected to the grounded conductor of this system. The identified conductor shall be connected to the screw shell of all lampholders.

*Exception:* Identification need not be maintained between switch and equipment controlled.

## B. Terminals.

All devices provided with terminals for the attachment of conductors 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.

1. The terminals of lighting panelboards and of devices having a normal rating exceeding 30 amperes need not be marked for identification, except as required in paragraphs 5 and 6 below for polarized receptacles for attachment plugs and polarized attachment-plug caps.
2. The terminals of utilization appliances need not be marked to indicate the proper connection to the grounded conductor. If a terminal of an utilization appliance which includes single-pole switches is marked for identification, the switches shall not be connected in the identified conductor of the circuit.

## 312. B. Terminals—Continued.

3. The terminals of portable appliances need not be marked for identification.
4. Devices, to the terminals of which only one side of the line is connected, need not have terminals marked for identification.
5. Two-wire attachment-plug receptacles without screw shells, and two-wire attachment-plug caps, unless of the polarity type, need not have their terminals marked for identification. Two-wire polarized receptacles for attachment plugs and polarized attachment-plug caps shall have the terminal intended for connection to the grounded conductor marked for identification.
6. Three-wire attachment-plug receptacles and three-wire attachment-plug caps, in which one terminal may be used for the connection of a grounding conductor, shall have such terminal identified in a manner differing from that specified in rule 312, C. The other terminals need not be marked for identification.
7. In the case of devices with screw shells, the identified terminal shall be the one connected to the screw shell. This does not apply to screw shells which serve as plug fuseholders.
8. In the case of screw-shell devices with attached leads, the conductor attached to the screw shell shall have white or natural-gray finish. The outer finish of the other conductor shall be of a solid color that will not be confused with the white or natural-gray finish which is to indicate the grounded conductor.

## C. Means of Identification of Terminals.

The marking of terminals shall be done by means of a metallic plated coating substantially white in color, as nickel or zinc, or the terminals may be of material substantially white in color. The other terminals shall be of a readily distinguishable different color.

**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. Conductors in Hazardous Locations.**

Conductors in locations where inflammable gas normally exists shall be in grounded rigid metal conduit. All fittings and outlets for conduit shall be electrically and mechanically continuous with the conduit, and the conduit shall be sealed by the use of suitable potheads or equivalent devices to prevent entrance of gases.

Conductors in locations where inflammable flyings normally exist shall be in grounded rigid metal conduit or cable approved for the purpose.

**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. SPLICING AND TAPING.**

Conductors shall be so spliced or joined as to be mechanically and electrically secure without solder and, unless made with a suitable splicing device, shall then be soldered with a fusible metal or alloy.

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. UNINSULATED CONDUCTORS.**

Uninsulated conductors may be used in the following cases under the conditions specified below:

1. As a grounded neutral service conductor, provided the secondaries of the supplying system operate at not more than 208 volts to ground and the conditions specified in rule 93 for a common grounding conductor are met. Except in the service drop, such an uninsulated service conductor shall be part of an approved type of service cable or shall be installed in a rigid metal raceway.
2. As a grounding conductor for equipment, as a common grounding conductor, or as an independent circuit-grounding conductor if used where a common grounding conductor is permissible. (See section 9 for installation method.)

**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.

**320. A. Accessibility, Marking, and Installation—Con.**

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, or where the controller or disconnecting means is capable of being locked in the "off" position.

*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. 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.
4. Oil switches and oil circuit-breakers shall be marked with the following data:
  - (a) Manufacturer's name and address.
  - (b) Manufacturer's type and designation number.
  - (c) Rated amperes.
  - (d) Rated volts.
  - (e) 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.

**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. Control of Exit and Emergency Lights.**

In buildings where emergency and exit lamps are installed, the control switch shall be located where it will be under competent supervision.

**D. Control of Exit Lights in Assembly Halls.**

Exit lamps and all lamps normally kept lighted in halls, corridors, and any other parts of theaters and

**320. D. Control of Exit Lights in Assembly Halls—Con.**

other public assembly halls used by the audience except the general auditorium lighting, shall be supplied independently of the stage lighting, and shall be controlled from the lobby or other place convenient to the main entrance to the building. In addition to the control required by the foregoing, there may be—

1. A switch at the main service or on the control panel of special current source.
2. A switch located adjacent to the emergency switch, or an automatic light-actuated device approved for the purpose, to control separately those lights on the exterior of the building which are not required for illumination when there is sufficient daylight.

**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.) Flush snap switches, if mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces, shall be provided with covers of nonconducting material. (Usually grounded surfaces within 5 feet horizontally of the parts considered and within 8 feet vertically of the floor are considered within reach).

**322. WHERE SWITCHES ARE REQUIRED.****A. Service Switches.**

Suitable switches and fuses, or circuit-breakers, or equivalent devices shall be installed in all ungrounded service conductors connecting utilization installations to the main service conductors from either overhead or underground lines. If fuses are used, unless access to them is under the control of the electric service company, they shall be disconnected by opening the service switch.

## 322. A. Service Switches—Continued.

Service switches and fuses, or circuit-breakers, or equivalent devices shall be readily accessible and as close as practicable to the point where the service enters the building.

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.

If supply is from two or more different sources, the switch or switches controlling the supply shall be so constructed or arranged that it will be impossible to connect to one source unless the other is disconnected.

*Exception:* Floating batteries or supply units or systems normally operated in parallel.

## 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 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.

*Exception 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.

*Exception 2:* The switch need not open a grounded conductor. (See rule 310, B and C.)

*Exception 3:* A group of incandescent lamps on the same branch circuit may be disconnected by one single-pole switch in the ungrounded conductor.

*Exception 4:* One switch may serve to disconnect several motors and their starting devices from the source of supply, if it complies with rule 308.



## 322. B. Circuit Switches—Continued.

*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. 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.

### D. 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.

### E. Emergency Stop Switches.

On equipment where the failure of any part of the operating or control circuits may create a life hazard and on equipment where there is possibility of the operator being caught or injured in the normal operation of the machine (such as rolls, mixers, beaters, etc.), an emergency stop switch shall be provided accessible to the operator in his usual working location. This switch shall be of a different color from any other switches on the operating or control panel and shall be clearly marked "Emergency Stop." Such switch shall not be dependent upon the action of springs for opening but shall be positively opened by the movement of the operating member itself. Springs may, however, be used to accelerate the separation of current-carrying parts. The circuit shall be so arranged that once the emergency stop switch has been operated, the equipment

## 322. E. Emergency Stop Switches—Continued.

cannot be started without going through the normal starting sequence.

## 323. CHARACTER OF SWITCHES AND DISCONNECTORS.

## A. Interrupting Capacity of Switches.

Switches used otherwise than as disconnectors shall have a capacity such as to insure safe interruption, at the working voltage, of the greatest current which they will be required to carry continuously, and shall be marked with the current and voltage for which they are rated.

## B. Capacity of Disconnectors and Warning Signs.

Disconnectors shall be of suitable voltage and ampere rating for the circuit in which they are installed and shall be accessible only to properly qualified persons. They shall also be protected by signs warning against opening them while carrying current in excess of the safe opening limit.

*Note:* Interlocking arrangements are desirable to prevent opening of such disconnectors under loads beyond their safe opening capacity and locking arrangements to prevent accidental opening.

## C. Locking or Blocking.

Where dependence for maintaining an open circuit as a protection for persons against unexpected starting or energizing the circuit is put on certain switches or circuit-breakers, such switches or circuit-breakers shall be so arranged that they can be locked, blocked, or otherwise secured in the "Off" or "Open" position. (See rules 328, A and 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.

**323. C. Locking or Blocking—Continued.**

*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 electric 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 electric energy.

If switches and fuses are in closed in metal cabinets and live terminals are accessible, greater hazard to one

**324. A. Automatic Disconnection—Continued.**

replacing a fuse 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 electric energy before they can be touched, switches shall be so placed or arranged that opening them will disconnect the fuses from all sources of electric 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.

Electric meters and control circuits of time switches may be connected on the supply side of the service switch and fuses or circuit breaker on alternating-current supply not exceeding 300 volts between conductors, provided no wiring or live parts are exposed and the connections are inaccessible to unauthorized persons.

**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.

**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 effectively 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.

**327. Guarding Live Parts—Continued.****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, if used to comply with the requirement in rules 308 (5); 323, C; 329, H2; and 363, D, shall be provided with means for locking or sealing the switch in the "Off" position.

**B. Locks for Disconnectors.**

Inclosed disconnectors shall have provisions for locking in both open and closed positions, where accessible to unqualified persons.

## 328. Inclosed Air-Break Switches—Continued.

**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 (ac or dc), 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.**

Switches of the inclosed type shall be externally operable, and the external operating handle (if one is used) 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 effectively grounded according to the provisions of rule 304, C.

*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.

## 329. Control Equipment—Continued.

## B. Material for Inclosures.

Cast metal for inclosures whether of iron or other metal, shall be at least  $\frac{1}{8}$ -inch in thickness at every point and of greater thickness at reinforcing ribs and door edges; except that die-cast metal may be not less than  $\frac{3}{32}$  inch in thickness for an area greater than 24 square inches or having any dimension greater than 6 inches, and may be not less than  $\frac{1}{16}$  inch in thickness for an area of 24 square inches or less, or having no dimension greater than 6 inches. Cast metal shall be at least  $\frac{1}{4}$ -inch in thickness at threaded holes for conduit.

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 gage not less than that given in table 1.

TABLE 1.—*Thickness of inclosures*

Maximum volume of inclosure	Maximum area of any surface	Maximum dimension	Minimum thickness of metal—U. S. Std. Gage	
			Without supporting frame	With supporting frame or equivalent reinforcing
<i>cu ft</i>	<i>sq in</i>	<i>in.</i>		
$\frac{3}{4}$	-----	12	20	24
1	-----	18	18	20
-----	360	24	16	18
-----	1, 200	48	14	16
-----	1, 500	60	12	16
-----	Over 1, 500	-----	10	16

Wire screening used for inclosures shall conform to the following:

Maximum opening in screen

Minimum wire size,  
Steel wire gage

$\frac{1}{2}$  inch ----- No. 16

More than  $\frac{1}{2}$  inch and not more than 2 inches ----- No. 12

If the opening is more than one-half inch, the inclosure shall not be less than 4 inches from any live part.



## 329. Control Equipment—Continued.

**C. Clearances.**

1. There shall be sufficient space within the inclosure to permit uninsulated parts of wire terminals to be separated so as to prevent their coming in contact with each other. Inclosures shall be such as to permit proper wire connections to be made with adequate spacing of the terminals and ends of conductors from adjacent points of the inclosures.
2. Exposed nonarcing current-carrying parts within the inclosures shall have an air space between them and the uninsulated part of the inclosure of at least  $\frac{1}{2}$  inch for 750 volts or less, except that in a controller or other small device rated at not more than one horsepower and 300 volts and having an inclosure adequately rigid, the spacing may be less than  $\frac{1}{2}$  inch but not less than  $\frac{1}{8}$  inch in air nor less than  $\frac{1}{4}$  inch over the surface of insulating material. Inclosures of sizes, materials, or forms not having adequate rigidity shall have greater spacing. A suitable lining of insulating material not less than  $\frac{1}{32}$  inch in thickness may be provided in lieu of the air space of  $\frac{1}{2}$  inch.

**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. Rating of Controller.**

A controller shall have appropriate ratings of voltage, frequency, and horsepower.

**F. Marking of Controllers.**

1. Controllers should be marked to indicate the duty for which they are designed, such as starting, intermittent, varying, continuous, etc.
2. Controllers shall be marked with their ratings in volts and horsepower and in addition if for alternating current, the cycles and number of phases.

## 329. F. Marking of Controllers—Continued.

3. Parts of controllers which are operated manually (controller handles, push-button stations) shall be marked, if necessary, to indicate proper operation.
4. Every controller shall be provided with a wiring diagram and, where practicable, this diagram shall be permanently attached to the controller or its mounting. All incoming and outgoing terminals of the control equipment shall be 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.

5. Field rheostats shall be marked to indicate the total ohms, volts, ampere capacity of first step, and ampere capacity of last step.
6. A thermal cutout used as part of the control equipment shall be marked with the maximum rating of the fuse with which it can be used safely.

## G. Guarding Live Parts.

1. Controllers and electric remote-control stations operating at 50 volts or more between conductors shall be guarded against accidental contact of persons with live parts by inclosure or guarding or location.
2. Manual controllers and manually operated electric remote-control stations operating at more than 150 volts to ground shall be externally operable.
3. Controllers shall be guarded against contact with live parts by conducting objects by inclosure or guarding or location. Consideration shall be given to possible hazards, from above, from cranes or other moving apparatus; from below by objects placed under the controller mounting; and from objects being carried by persons, such as pipe, tools, etc.

## 329. Control Equipment—Continued.

**H. Protection for Workmen.**

1. Any controller installation operating at over 300 volts to ground which, for any reason, must be alive when maintenance work is being done shall comply with the following:
  - (a) Live parts shall be accessible only to qualified and authorized persons.
  - (b) An insulating mat or platform shall be provided on which a person must stand while inspecting or working on the controller.
  - (c) Any conducting surfaces within  $3\frac{1}{2}$  feet of the controller shall be provided with insulating guards.
  - (d) Non-current-carrying metal parts of the controller, such as the mounting frame and metal shields, shall not be grounded and shall be installed effectively insulated from ground.

*Note:* See also part 4 for safe practices in working on live equipment.

2. Means shall be provided for disconnecting all ungrounded conductors from the controller, except that controllers described in subparagraph 1 above are not required to have such disconnecting means if the controller opens all ungrounded conductors to the motor. The disconnecting means may be in the same inclosure or on the same panel as the controller. If not within sight of the controller, it shall be provided with means for locking it in the open position.

**I. Guarding Arcing Parts.**

Controllers shall be so located or shielded as to protect operators and other persons in the vicinity from burns or eye-flash which might result from arc-rupturing parts and so as to prevent arcing to adjacent surfaces. For this latter purpose, controllers installed without inclosure, and controllers

## 329 I. Guarding Arcing Parts—Continued.

whose inclosure is built up during or after installation of the controller, shall have the air spaces (or barriers) given in table 2 between arc-rupturing parts and the walls of metal inclosure or other adjacent surface.

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	
	dc and ac		dc		ac		dc and ac	
	300 volts	750 volts	300 volts	750 volts	300 volts	750 volts	300 volts	750 volts
5.....	<i>Inches</i> 1¾	<i>Inches</i> 3	<i>Inches</i> 4	(1)	<i>Inches</i> 1¾	<i>Inches</i> 3	<i>Inches</i> ¾	<i>Inches</i> 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)

<sup>1</sup> Barrier.

NOTES.—All distances to be measured from contact tips or arc horns.  
Voltage values given are between conductors.

## J. Location of Controller.

All points from which the motor is controlled shall be within sight of the motor unless that is impracticable, in which case there shall be means readily available to the person inspecting the motor for preventing operation of the controller.

## K. Overcurrent Protection.

Control equipment shall include an automatic device which will interrupt the electric power if the current exceeds a predetermined value. Such overload protection need not be a part of the controller but may be a separate unit. If a part of the controller, such overload protection shall conform to all applicable rules for the control equipment.



**329. Control Equipment—Continued.****L. Under-Voltage Protection.**

If the automatic restarting of a motor on restoration of voltage may result in injury to any person, under-voltage protection shall be furnished. See 340, D.

**M. Open-Phase or Phase-Reversal Protection.**

If the motor operates equipment which is of such a nature that the opening of one phase of a polyphase circuit or the reversal of a phase or phases would result in possible injury to any person, means shall be provided which will prevent starting of the motor under such a condition.

**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 frame-work being installed if necessary.

**332. ARRANGEMENT AND IDENTIFICATION.**

Connections, wiring, and equipment of switchboards and panelboards shall be arranged in an orderly manner

**332. Arrangement and Identification—Continued.**

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 effectively 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

**335. A. Inclosure of Parts at More Than 150 Volts to Ground—Continued.**

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 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 having current-carrying parts exposed on back to passersby 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 electric energy before they can be touched.

**336. A. Disconnection of Fuses—Continued.**

2. So that they can be disconnected from all sources of electric 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 volts to ground and should be provided if the voltage is less than 150 volts to ground.

**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 holders 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.



## 337. Panelboards—Continued.

**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, except as permitted by rule 307.

**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

**340. B. Adjustable-Speed Motors—Continued.**

that the field cannot be weakened sufficiently to permit a dangerous speed, and so that the motor cannot be started under weakened field unless the motor is designed for such starting.

**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 effectively 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 cannot 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 effectively grounded as required by rule 304, C, unless they are bonded together electrically and

**344. Grounding Machine Frames—Continued.**

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 American Standard Safety Code for the Protection of the Heads, Eyes, and Respiratory Organs, ASA Z2, for mechanical and optical protection.)

**351. GROUNDING OF FURNACE FRAMES.**

The outside noncurrent-carrying metallic frames of furnaces shall be effectively grounded if they contain cur-



**351. Grounding of Furnace Frames—Continued.**

rent-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 shall be in accordance with section 13 of the rules for stations (part 1).

**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 between conductors, 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. FIXTURES.

## A. Grounding.

The exposed noncurrent-carrying metal parts of all lighting fixtures, receptacle plates, and switch plates and other similar fixed electric devices shall be effectively grounded when used under the following circumstances (for exception, see rule 304, C.):

1. If in locations where explosives, inflammable gas, or inflammable flyings exist in dangerous quantities.
2. If within reach of bathtubs, shower baths, plumbing fixtures, steam piping, or other grounded metal surfaces of the building. Metal pull chains used at these locations shall be provided with insulating links. (Usually grounded surfaces within 5 feet horizontally of the parts considered and within 8 feet vertically of the floor are considered within reach).
3. If connected to circuits operating in excess of 150 volts to ground, regardless of location.

*Exception:* Grounding is not required if the fixture, shell of socket, lamp guards, etc., are made of or covered with suitable insulating material.

## B. Gas Piping as Electrode.

Gas piping may serve as the grounding electrode for fixtures located at a considerable distance from water piping. (See section 9 for method).

## C. Polarizing Lampholders.

On grounded systems the center contacts of lampholders shall be connected to the ungrounded side of the system, and the inner screw shells of the devices to the grounded side or neutral.

*Note:* This is in order to reduce the liability of break-down 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.

**361. RECEPTACLE FOR CONVENIENCE OUTLET.**

Receptacles installed for the attachment of portable cords shall be of a type not suitable for use with screw-shell-base devices.

**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 signs shall be effectively grounded, unless they are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons. This does not apply to signs of the portable incandescent lamp type.

**D. Control.**

Electric signs, other than the portable type, 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. LAMPS IN SERIES CIRCUITS.****A. In or on Buildings.**

Series lamps mounted in buildings or on external walls of buildings shall be installed only by permission of the administrative authority.

**B. 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.

**C. 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 han-



**366. Safe Access to Arc Lamps—Continued.**

dled, 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 concerne'd

**SEC. 37. PORTABLE APPLIANCES, CABLES AND CONNECTORS, AND INSECT ELIMINATORS**

[Not including those for communication systems]

**370. INSULATION.**

Portable appliances and 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 appliances 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. Grounding Noncurrent-Carrying Metal Parts.**

Portable appliances and devices operating on circuits of more than 150 volts to ground, shall have their exposed metal frames grounded except (1) motors, if guarded; and (2) electrically heated appliances exempted by the administrative authority. The exposed metal frames of portable appliances and devices used in hazardous locations as listed in rule 307, A, shall be effectively grounded, regardless of the voltage of the circuit.

The effective grounding of exposed metal frames of portable appliances and devices (especially when used in locations such as bathrooms, laundries, etc., under conditions where persons may easily touch

371. A. Grounding Noncurrent-Carrying Metal Parts—Con. grounded surfaces at the same time as the appliance or device) is recommended.

*Note:* Such grounding may be obtained by the use of a three-wire portable cord with the portable appliance or device, one wire being used for the grounding conductor and the connectors being properly designed so that wrong connections cannot be made by the user of the device. Safety may be accomplished and the need for grounding eliminated in many cases by insulating the metal frame from contact by persons, or by isolation of the device.

It is recommended that in industrial establishments portable lamps which are to be used in conductive locations, be operated at 32 volts or less between conductors through the use of step-down transformers, thus obviating the need for grounding such portable equipment.

**B. Sockets and Fixtures of Insulating Material.**

Sockets, fixtures, lamp guards or similar devices constructed or covered with suitable insulating material may be used in lieu of grounded metal devices, and should be used in locations such as bathrooms, laundries, etc.

**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 when the circuit is opened.

**B. Design of Connectors.**

Connectors shall be so constructed (with guards when necessary) that the person using them cannot inadvertently come in contact with live parts, or be burned by arcing when interrupting the 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.

**372. Cable Connectors—Continued.****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 Appliances and Devices.**

Where portable appliances and 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. Identification of an equipment grounding conductor of a portable cable may be the absence of insulating covering, but if an individual covering is provided for this conductor it shall be finished to show a green color.

*Note:* If portable cable containing a conductor identified as provided above is not available, the identifying color may be applied to one of the insulated conductors of the cable where the conductor is exposed at terminals.

**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

**374. A. Voltage Limit of Portables—Continued.**

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 equipment in series with lamps on trolley circuits, the equipment 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. (See rule 361.)

**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 cannot 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 socket and 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



## 374. E. Worn and Defective Portables—Continued.

to users by wire strands piercing the insulation or becoming exposed through abrasion of the covering.

## 375. PORTABLE OUTDOOR EQUIPMENT OF MORE THAN 750 VOLTS BETWEEN CONDUCTORS.

## A. Scope.

This rule is intended to apply to equipment supplied through portable cable and used for such outdoor surface work as well-drilling, strip mining, quarrying, dredging, shoveling, and log sawing.

## B. Cables.

## 1. INSULATION.

Cables, wiring, and electric equipment shall be insulated for not less than line-to-line voltage.

## 2. TRAILING CABLES.

(a) Trailing cables used for connecting an electric supply to mining machines, dredges, shovels, and similar equipment shall be of sturdy construction and suitable for the intended service.

(b) It is recommended that trailing cables be in continuous lengths. If splices are made they should be equivalent mechanically and electrically to the cable in which they are made.

(c) The individual conductors of trailing cables shall be so connected to equipment and to the source of supply as to give solid and firm connections without injury to the cable and so that the cables cannot be inadvertently disconnected. Such connections shall be weatherproof and there shall be no exposed current-carrying parts.

## C. Relays.

Each complete metallic circuit (not separated by insulation as in transformers) shall be equipped with a relay which shall operate on occurrence of a

**375. C. Relays—Continued.**

ground fault on the circuit to deenergize the faulty circuit or equipment.

**D. Grounding.**

Machinery frames shall be effectively grounded in the manner required by section 9.

**E. Impedors.**

If it desired to provide protection during the interval of time the fault current exists, the use of an impedor connected between the transformer secondary neutral and the grounding point is recommended. The value of this impedor should be such that the voltage which may occur between the machinery frame and ground will not exceed 100 volts.

**376. INSECT ELIMINATORS.**

Electric insect eliminators shall be of such low current output as not to be a hazard to persons or property, or they shall be installed and guarded or isolated in accordance with rules 304, C, and 306, A.

**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, suitable cable, metal molding, or flameproof and waterproof nonmetallic ducts the exposed metallic parts of which shall be effectively grounded.

## 380. Guarding Live and Moving Parts—Continued.

**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 suitable cable 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 effectively grounded.

No part of any electric circuit having a rated system or circuit voltage in excess of 750 volts dc or 550 volts ac shall be used for any control or operating circuit. No signaling push buttons shall be used in circuits of more than 300 volts to ground. Circuits of higher rated system or circuit voltage may, however, be used in machine rooms or penthouses for the operation of motors, provided that all operating and signal wiring is thoroughly insulated from such power circuits and all machine frames and hand-ropes are effectively grounded.

The maximum system or circuit voltage permitted in the operating devices of automatic-operation elevators having operating devices in the car and at landings shall be 300 volts to ground.

**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,

**380. D. Material for Guards—Continued.**

transformers, fuses, circuit-breakers, switches, and other devices, shall consist of cabinets, casings, or shields of effectively 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 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 nongrounded 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 cannot 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 connected to ground.



**380. Guarding Live and Moving Parts—Continued.****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 shall be effectively grounded or protected by effectively 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 should be provided which will prevent contact of conducting parts with the overhead wire if the boom is raised against it.

**381. Grounding Noncurrent-Carrying Parts—Continued.****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. Disconnecter 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 col-

382. C. Disconnecter for Third-Rail Collector—Continued.  
lectors so that these may be deenergized when the current supply is from the overhead trolley.
383. CONTROL OF MOVEMENT OF INDUSTRIAL LOCOMOTIVES, CARS, CRANES, AND ELEVATORS.

**A. Locking or Removable Handles.**

Means shall be provided whereby the operator (whether motorman or elevator attendant) can prevent the starting of the equipment by unauthorized persons while he is absent from his post.

*Note:* Removable reverse levers or controller handles and locked doors to the operator's cab or elevator hoistway are among the most effective means.

**B. Location of Controllers.**

The car control lever of passenger elevators should be located so that the operator can readily face the principal car opening. For cars and traveling cranes, the car control should be so located that the operator can readily see in the direction of travel.

It is recommended that the control levers of traveling cranes be located in the same relative position each to the other in all the cages of cranes.

**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 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.

**383. D. Reverse-Phase Relays—Continued.**

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.

**SECTION 39. TELEPHONE AND OTHER COMMUNICATION APPARATUS ON CIRCUITS EXPOSED TO SUPPLY LINES OR LIGHTNING****390. PROTECTIVE REQUIREMENTS.****A. General 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 either lightning, supply lines of more than 400 volts to ground, or induction of more than 150 volts between terminals of the communication equipment and ground from supply circuits under normal conditions, provisions against shock to persons handling apparatus, shall be made by one of the following methods:

1. The use of suitable protective devices such as fuses and arresters operating at 750 volts to ground and, for conditions of unusual exposure, additional devices such as auxiliary arresters, neutralizing transformers, drainage coils or insulating transformers.



**390. A. General Requirements—Continued.**

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. (This method may be used only where apparatus is accessible to none but authorized persons.)

**B. Fire and Police Alarm Boxes.**

Such signaling devices as fire and police alarm and associated 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 effectively grounded wherever the character of service gives valid objection to the use of arresters or transformers on the signal circuit.

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.

Police alarm boxes, where connected to overhead police alarm circuits, should be protected by arresters, operating at not more than 750 volts, placed in the connecting leads outside the box.

**391. GUARDING CURRENT-CARRYING PARTS.****A. Current-Carrying Parts.**

Telephone or other communication apparatus which is 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

**391. A. Current-Carrying Parts—Continued.**

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 where required to be guarded shall be guarded by shields of effectively grounded metal (such as metal armor) or of nonabsorptive insulating material (such as flexible insulating tubing) or suitable insulating coverings for the individual conductors. (See 390, A, 2.)

**C. Shields for Portable Cords.**

Where no protective device is installed 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. GROUNDING.**

The ground connections for outside installations of cable protectors employed solely to prevent electrical damage to the cable need not conform with the requirements of this rule.

**A. Methods.**

Arresters and, where required, exposed non-current-carrying metal parts shall be grounded in the following manner:

1. The grounding conductor shall preferably be of copper (or other material which will not corrode excessively under the prevailing conditions of use) and shall be not less than No. 18 (0.040 inch) in size, and where within buildings shall be covered with a suitable insulation.

**392. A. Methods—Continued.**

If necessary to guard the grounding conductor from mechanical damage (on poles or where a grounding conductor on the outside of building walls is near a roadway, sidewalk, or pathways, thus 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 grounding conductor shall preferably be connected to a cold-water pipe. In the absence of a water pipe, connection may be made to a continuous underground metallic gas-piping system, to metallic structures when effectively grounded, or to a ground rod or pipe driven into permanently damp earth. If a gas-pipe electrode is used, connection shall be made between the gas meter and the street main. Steam or hot-water pipes should not be used for ground connections. Driven rods or driven pipes used as ground connections for protectors shall not be also used as ground connections for electric-supply circuits or electric apparatus. The requirement of separate driven rods or pipes for protectors and for electric supply circuit grounding, or the use of other separate grounds, does not prohibit bonding together such grounds where such bonding seems desirable. Where water or gas pipes are used for a ground connection, attachment to such pipes shall not be made at the same point as 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.

## 392. Grounding—Continued.

**C. Connecting Grounding Conductors to Driven Rod or Pipe or Other Metallic Structure.**

Grounding conductors shall be so attached to the rod, pipe or metallic structure as to give reliable connection, both mechanically and electrically, and in such a manner as to prevent excessive corrosion when the joint is buried in the earth.







