1905

"NATIONAL ELECTRICAL CODE."

RULES AND REQUIREMENTS

OF THE

National Board of Fire Underwriters

FOR THE INSTALLATION OF

ELECTRIC WIRING

AND

APPARATUS

As Recommended by the

UNDERWRITERS' NATIONAL ELECTRIC ASSOCIATION

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EDITION OF 1905

The National Electrical Code was originally drawn in 1897 as the result of the united efforts of the various Insurance, Electrical, Architectural and allied interests which through the National Conference on Standard Electrical Rules, composed of delegates from various National Associations, unanimously voted to recommend it to their respective associations for approval or adoption; and is here presented by the National Board of Fire Underwriters with the various amendments and additions which have been made since that time by them.

The following is a list of the Associations composing the National Conference on Standard Electrical Rules:—

AMERICAN INSTITUTE OF ARCHITECTS.
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
AMERICAN STREET RAILWAY ASSOCIATION.
ASSOCIATED FACTORY MUTUAL FIRE INS. CO'S.
ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.
INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
NATIONAL BOARD OF FIRE UNDERWRITERS.
NATIONAL ELECTRIC LIGHT ASSOCIATION.
NATIONAL ELECTRICAL CONTRACTORS' ASSOCIATION.
UNDERWRITERS' NATIONAL ELECTRIC ASSOCIATION.

1st Edition

GENERAL PLAN

GOVERNING THE ARRANGEMENT OF RULES.

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CLASS E.—**MISCELLANEOUS.** Rules 64 to 67.

CLASS F.—**MARINE WORK.** Rules 68 to 83.

GENERAL SUGGESTIONS.

In all electric work, conductors, however well insulated, should always be treated as bare, to the end that under no conditions, existing or likely to exist, can a ground or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to the minimum.

In all wiring special attention must be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of conductors, and securing and attaching of fittings, are specially conducive to security and efficiency, and will be strongly insisted on.

In laying out an installation, except for constant-current systems, every reasonable effort should be made to secure distribution centers located in easily accessible places, at which points the cut-outs and switches controlling the several branch circuits can be grouped for convenience and safety of operation. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

The use of wire-ways for rendering concealed wiring permanently accessible is most heartily indorsed and recommended; and this method of accessible concealed construction is advised for general use.

Architects are urged, when drawing plans and specifications, to make provision for the channeling and pocketing of buildings for electric light or power wires.

CLASS A.

STATIONS AND DYNAMO ROOMS.

Includes Central Stations, Dynamo, Motor and Storage-Battery Rooms, Transformer Substations, Etc.

1. Generators.

a. Must be located in a dry place.

b. Must never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings of combustible materials.

c. Must be thoroughly insulated from the ground wherever feasible. Wooden base-frames used for this purpose, and wooden floors which are depended upon for insulation where, for any reason, it is necessary to omit the base-frames, must be kept filled to prevent absorption of moisture, and must be kept clean and dry.

Where frame insulation is impracticable, the Inspection Department having jurisdiction may, in writing, permit its omission, in which case the frame must be permanently and effectively grounded.

A high-potential machine, which on account of great weight or for other reasons, cannot have its frame insulated from the ground, should be surrounded with an insulated platform. This may be made of wood, mounted on insulating supports, and so arranged that a man must always stand upon it in order to touch any part of the machine.

In case of a machine having an insulated frame, if there is trouble from static electricity due to belt friction, it should be overcome by placing near the belt a metallic comb connected with the earth, or by grounding the frame through a resistance of not less than 300,000 ohms.

1. Generators—Continued.

d. Constant potential generators, except alternating current machines and their exciters, must be protected from excessive current by safety fuses or equivalent devices of *approved* design.

For two-wire, direct-current generators, single pole protection will be considered as satisfying the above rule, provided the safety device is located in the lead not connected to the series winding. When supplying three-wire systems, the generators should be so arranged that these protective devices will come in the outside leads

For three wire, direct-current generators, a safety device must be placed in each armature, direct-current lead, or a double pole, double trip circuit breaker in each outside generator lead and corresponding equalizer connection.

In general, generators should preferably have no exposed live parts and the leads should be well insulated and thoroughly protected against mechanical injury. This protection of bare live parts against accidental contact would apply also to any exposed, uninsulated conductors outside of the generator and not on the switchboard, unless their potential is practically that of the ground.

Where the needs of the service make the above requirements impracticable, the Inspection Department having jurisdiction may, in writing, modify them.

e. Must each be provided with a waterproof cover.

f. Must each be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

g. Terminal blocks when used on generators must be made of *approved* non-combustible, non-absorptive insulating material, such as slate, marble or porcelain.

2. Conductors.

From generators to switchboards, rheostats or other instruments, and thence to outside lines.

a. Must be in plain sight or readily accessible.

2. Conductors—Continued.

Wires from generator to switchboard may, however, be placed in a conduit in the brick or cement pier on which the generator stands, provided that proper precautions are taken to protect them against moisture and to thoroughly insulate them from the pier. If lead-covered cable is used, no further protection will be required, but it should not be allowed to rest upon sharp edges which in time might cut into the lead sheath, especially if the cables were liable to vibration. A smooth runway is desired. If iron conduit is provided, double braided rubber-covered wire (see No. 47) will be satisfactory.

b. Must have an *approved* insulating covering as called for by rules in Class "C" for similar work, except that in central stations, on exposed circuits, the wire which is used must have a heavy braided, non-combustible outer covering.

Bus bars may be made of bare metal.

Rubber insulations ignite easily and burn freely. Where a number of wires are brought close together, as is generally the case in dynamo rooms, especially about the switchboard, it is therefore necessary to surround this inflammable material with a tight, non-combustible outer cover. If this is not done, a fire once started at this point would spread rapidly along the wires, producing intense heat and a dense smoke. Where the wires have such a covering and are well insulated and supported, using only non-combustible materials, it is believed that no appreciable fire hazard exists, even with a large group of wires.

c. Must be kept so rigidly in place that they cannot come in contact.

d. Must in all other respects be installed with the same precautions as required by rules in Class "C" for wires carrying a current of the same volume and potential.

e. In wiring switchboards, the ground detector, voltmeter, pilot lights and potential transformers must be connected to a circuit of not less than No. 14 B. & S. gage wire that is protected by an

2. Conductors—Continued.

approved fuse, this circuit is not to carry over 660 watts.

Voltmeter switches having concealed connections must be plainly marked, showing connections made.

3. Switchboards.

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

Special attention is called to the fact that switchboards should not be built down to the floor, nor up to the ceiling. A space of at least ten or twelve inches should be left between the floor and the board, except when the floor about the switchboard is of concrete or other fire-proof construction, and three feet, if possible, between the ceiling and the board, in order to prevent fire from communicating from the switchboard to the floor or ceiling, and also to prevent the forming of a partially concealed space very liable to be used for storage of rubbish and oily waste.

b. Must be made of non-combustible material or of hardwood in skeleton form, filled to prevent absorption of moisture.

If wood is used all wires and all current carrying parts of the apparatus on the switchboard must be separated therefrom by non-combustible, non-absorptive insulating material.

c. Must be accessible from all sides when the connections are on the back, but may be placed against a brick or stone wall when the wiring is entirely on the face.

If the wiring is on the back, there should be a clear space of at least eighteen inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall. The space back of the board should not be closed in, except by grating or netting either at the sides, top, or bottom, as such an enclosure is almost sure to be used as a closet for clothing or for the storage of oil cans, rubbish, etc. An open space is much more likely to be kept clean, and is more convenient for making repairs, examinations, etc.

3. Switchboards—Continued.

d. Must be kept free from moisture.

e. On switchboards the distances between bare live parts of opposite polarity must be made as great as practicable, and must not be less than those given for tablet-boards (see No. 53 A).

4. Resistance Boxes and Equalizers.

(*For construction rules, see No. 60.*)

a. Must be placed on a switchboard or, if not thereon, at a distance of at least a foot from combustible material, or separated therefrom by a non-combustible, non-absorptive, insulating material, such as slate or marble.

The attachments of the separating material to its support and to the device must be independent of each other, and the separating material must be continuous between the device and the support; that is, the use of porcelain knobs will not be accepted.

b. Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided that they do not carry or control the main current nor constitute the regulating resistance of the device.

When so used, lamps must be mounted in porcelain receptacles upon non-combustible supports, and must be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated. They must in all cases be provided with a name-plate, which shall be permanently attached beside the porcelain receptacle or receptacles and stamped with the candle-power and voltage of the lamp or lamps to be used in each receptacle.

c. Wherever insulated wire is used for connections between a rheostat and its contact plate, the insulation must be slow burning (see No. 43). For large field rheostats and similar resistances,

4. Resistance Boxes and Equalizers—Continued.

where the contact plates are not mounted upon them, the connecting wires may be run together in groups so arranged that the maximum difference of potential between any two wires in a group shall not exceed 75 volts. Each group of wires must either be mounted on non-combustible, non-absorptive insulators giving at least ½ inch separation from surface wired over, or, where it is necessary to protect the wires from mechanical injury or moisture, be run in *approved* lined conduit or equivalent.

5. Lightning Arresters.

(*For construction rules, see No. 63.*)

a. Must be attached to each wire of every overhead circuit connected with the station.

It is recommended to all electric light and power companies that arresters be connected at intervals over systems in such numbers and so located as to prevent ordinary discharges entering (over the wires) buildings connected to the lines.

b. Must be located in readily accessible places away from combustible materials, and as near as practicable to the point where the wires enter the building.

In all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines must be avoided as far as possible.

The switchboard does not necessarily afford the only location meeting these requirements. In fact, if the arresters can be located in a safe and accessible place away from the board, this should be done, for, in case the arrester should fail or be seriously damaged there would then be less chance of starting arcs on the board.

c. Must be connected with a thoroughly good and permanent ground connection by metallic strips or wires having a conductivity not less than that of a

5. Lightning Arresters—Continued.

No. 6 B. & S. gage copper wire, which must be run as nearly in a straight line as possible from the arresters to the ground connection.

Ground wires for lightning arresters must not be attached to gas pipes within the buildings.

It is often desirable to introduce a choke coil in circuit between the arresters and the dynamo. In no case should the ground wires from lightning arresters be put into iron pipes, as these would tend to impede the discharge.

d. All choke coils or other attachments, inherent to the lightning protection equipment, shall have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit in the station.

6. Care and Attendance.

a. A competent man must be kept on duty where generators are operating.

b. Oily waste must be kept in *approved* metal cans and removed daily.

Approved waste cans shall be made of metal, with legs raising can three inches from the floor, and with self-closing covers.

7. Testing of Insulation Resistance.

a. All circuits except such as are permanently grounded in accordance with No. 13 A must be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground wires from detectors must not be attached to gas pipes within the building.

b. Where continuously indicating detectors are not feasible, the circuits should be tested at least once per day, and preferably oftener.

c. Data obtained from all tests must be pre-

7. Testing of Insulation Resistance—Continued.

served for examination by the Inspection Department having jurisdiction.

These rules on testing to be applied at such places as may be designated by the Inspection Department having jurisdiction.

8. Motors.

a. Must be thoroughly insulated from the ground wherever feasible. Wooden base-frames used for this purpose, and wooden floors which are depended upon for insulation, where, for any reason, it is necessary to omit the base-frames, must be kept filled to prevent absorption of moisture, and must be kept clean and dry.

Where frame insulation is impracticable, the Inspection Department having jurisdiction may, in writing, permit its omission, in which case the frame must be permanently and effectively grounded.

A high-potential machine which, on account of great weight or for other reasons, cannot have its frame insulated, should be surrounded with an insulated platform. This may be made of wood, mounted on insulating supports, and so arranged that a man must stand upon it in order to touch any part of the machine.

In case of a machine having an insulated frame, if there is trouble from static electricity due to belt friction, it should be overcome by placing near the belt a metallic comb connected to the earth, or by grounding the frame through a resistance of not less than 300,000 ohms.

b. Must be wired with the same precautions as required by rules in class "C" for wires carrying a current of the same volume and potential.

The motor leads or branch circuits must be designed to carry a current at least 25 per cent greater than that for which the motor is rated, in order to provide for the inevitable occasional overloading of the motor, and the increased current required in starting, without overfusing the wires, but where the wires under this rule would be over-fused, in order to provide for the starting current, as in the case of many of the alternating current motors, the wires must be of such size as to be properly protected by these larger fuses.

8. Motors—Continued.

The use of voltages above 550 is rarely advisable or necessary, and will only be approved when every possible safeguard has been provided. Plans for such installations should be submitted to the Inspection Department having jurisdiction before any work on them is begun.

c. Each motor and resistance box must be protected by a cut-out and controlled by a switch (see No. 17 *a*), said switch plainly indicating whether "on" or "off." With motors of one-fourth horse power or less, on circuits where the voltage does not exceed 300, No. 21 *d* must be complied with, and single pole switches may be used as allowed in No. 22 *c*. The switch and rheostat must be located within sight of the motor, except in cases where special permission to locate them elsewhere is given, in writing, by the Inspection Department having jurisdiction.

Where the circuit-breaking device on the motor-starting rheostat disconnects all wires of the circuit, the switch called for in this section may be omitted.

Overload-release devices on motor-starting rheostats will not be considered to take the place of the cut-out required by this section if they are inoperative during the starting of the motor.

The switch is necessary for entirely disconnecting the motor when not in use, and the cut-out to protect the motor from excessive currents due to accidents or careless handling when starting. An automatic circuit-breaker disconnecting all wires of the circuit may, however, serve as both switch and cut-out.

In general, motors should preferably have no exposed live parts.

d. Must have their rheostats or starting boxes located so as to conform to the requirements of No. 4.

The use of circuit-breakers with motors is recommended, and may be required by the Inspection Department having jurisdiction.

To be safe a rheostat should have as great a carrying capacity as the motor itself, or else the arm should have

8. Motors—Continued.

a strong spring-throw attachment, so arranged that it cannot remain at any intermediate position unless purposely held there. Specifications governing the construction of rheostats are given in No. 60.

Starting rheostats and auto-starters should be treated about the same as knife-switches, and in all wet, dusty, or linty places should be enclosed in dust-tight, fireproof cabinets. If a special motor room is provided, the starting apparatus and safety devices should be included within it. Where there is any liability of short-circuits across their exposed live parts being caused by accidental contacts, they should either be enclosed in cabinets, or else a railing should be erected around them to keep unauthorized persons away from their immediate vicinity.

e. Must not be run in series-multiple or multiple-series, except on constant-potential systems, and then only by special permission of the Inspection Department having jurisdiction.

f. Must be covered with a waterproof cover when not in use, and, if deemed necessary by the Inspection Department having jurisdiction, must be enclosed in an *approved* case.

From the nature of the question the decision as to what is an *approved* case must be left to the Inspection Department having jurisdiction to determine in each instance.

When it is necessary to locate a motor in the vicinity of combustibles or in wet or very dusty or dirty places, it is generally advisable to surround it with a suitable enclosure.

The sides of such enclosures should preferably be made largely of glass, so that the motor may be always plainly visible. This lessens the chance of its being neglected, and allows any derangement to be at once noticed.

g. Must, when combined with ceiling fans, be hung from insulated hooks, or else there must be an insulator interposed between the motor and its support.

h. Must each be provided with a name-plate, giving the maker's name, the capacity in volts and

8. Motors—Continued.

amperes, and the normal speed in revolutions per minute.

i. Terminal blocks when used on motors must be made of *approved* non-combustible, non-absorptive, insulating material, such as slate, marble or porcelain.

9. Railway Power Plants.

a. Each feed wire before it leaves the station must be equipped with an *approved* automatic circuit-breaker (see No. 52) or other device, which will immediately cut off the current in case of an accidental ground. This device must be mounted on a fireproof base, and in full view and reach of the attendant.

10. Storage or Primary Batteries.

a. When current for light and power is taken from primary or secondary batteries, the same general regulations must be observed as apply to similar apparatus fed from dynamo generators developing the same difference of potential.

b. Storage battery rooms must be thoroughly ventilated.

c. Special attention is directed to the rules for wiring in rooms where acid fumes exist (see No. 24, *i* to *k*).

d. All secondary batteries must be mounted on non-absorptive, non-combustible insulators, such as glass or thoroughly vitrified and glazed porcelain.

e. The use of any metal liable to corrosion must be avoided in cell connections of secondary batteries.

11. Transformers.

(*For construction rules, see No. 62.*)

(*See also Nos. 13, 13 A, 36.*)

a. In central or sub-stations the transformers must be so placed that smoke from the burning out of the coils or the boiling over of the oil (where oil filled cases are used) could do no harm.

If the insulation in a transformer breaks down, considerable heat is likely to be developed. This would cause a dense smoke, which might be mistaken for a fire and result in water being thrown into the building, and a heavy loss thereby entailed. Moreover, with oil-cooled transformers, especially if the cases are filled too full, the oil may become ignited and boil over, producing a very stubborn fire.

OUTSIDE WORK.

(*Light, Power and Heat. For Signaling Systems, see Class E.*)

ALL SYSTEMS AND VOLTAGES.

12. Wires.

a. Service wires must have an *approved* rubber insulating covering (see No. 41). Line wires, other than services, must have an *approved* weather-proof or rubber insulating covering (see Nos. 41 and 44). All tie wires must have an insulation equal to that of the conductors they confine.

In risks having private generating plants, the yard wires running from building to building are not generally considered as service wires, so that rubber insulation would not be required.

b. Must be so placed that moisture cannot form a cross connection between them, not less than a foot apart, and not in contact with any substance other than their insulating supports. Wooden blocks to which insulators are attached must be covered over their entire surface with at least two coats of waterproof paint.

c. Must be at least seven feet above the highest point of flat roofs, and at least one foot above the ridge of pitched roofs over which they pass or to which they are attached.

Roof structures are frequently found which are too low or much too light for the work, or which have been carelessly put up. A structure which is to hold the wires a proper distance above the roof in all kinds of weather must not only be of sufficient height, but must be substantially constructed of strong material.

d. Must be protected by dead insulated guard irons or wires from possibility of contact with other conducting wires or substances to which current may leak. Special precautions of this

12. Wires—Continued.

kind must be taken where sharp angles occur, or where any wires might possibly come in contact with electric light or power wires.

Crosses, when unavoidable, should be made as nearly at right angles as possible.

e. Must be provided with petticoat insulators of glass or porcelain. Porcelain knobs or cleats and rubber hooks will not be approved.

f. Must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered, to insure preservation, and covered with an insulation equal to that on the conductors.

All joints must be soldered, even if made with some form of patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these rules.

g. Must, where they enter buildings, have drip loops outside, and the holes through which the conductors pass must be bushed with non-combustible, non-absorptive insulating tubes slanting upward toward the inside.

For low potential systems the service wires may be brought into buildings through a single iron conduit. The conduit to be curved downward at its outer end and carefully sealed to prevent the entrance of moisture. The outer end must be at least one foot from any wood work and the inner end must enter a main cut-out cabinet in a manner similar to that described in fine print note under No. 25, Section *b*.

h. Electric light and power wires must not be placed on the same cross-arm with telegraph, telephone or similar wires, and when placed on the same pole with such wires the distance between the two inside pins of each cross-arm must not be less than twenty-six inches.

i. The metallic sheaths to cables must be permanently and effectively connected to "earth."

12. Wires—Continued

Trolley Wires.

j. Must not be smaller than No. 0 B. & S. gage copper or No. 4 B. & S. gage silicon bronze, and must readily stand the strain put upon them when in use.

k. Must have a double insulation from the ground. In wooden pole construction the pole will be considered as one insulation.

l. Must be capable of being disconnected at the power plant, or of being divided into sections, so that, in case of fire on the railway route, the current may be shut off from the particular section and not interfere with the work of the firemen. This rule also applies to feeders.

m. Must be safely protected against accidental contact where crossed by other conductors.

Guard wires should be insulated from the ground and should be electrically disconnected in sections of not more than 300 feet in length.

Ground Return Wires.

n. For the diminution of electrolytic corrosion of underground metal work, ground return wires must be so arranged that the difference of potential between the grounded dynamo terminal and any point on the return circuit will not exceed twenty-five volts.

It is suggested that the positive pole of the dynamo be connected to the trolley line, and that whenever pipes or other underground metal work are found to be electrically positive to the rails or surrounding earth, that they be connected by conductors arranged so as to prevent as far as possible current flow from the pipes into the ground.

12 A. Constant-Potential Pole Lines, Over 5,000 Volts.

(Overhead lines of this class unless properly arranged may increase the fire loss from the following causes:—

Accidental crosses between such lines and low-potential lines may allow the high-voltage current to enter buildings over a large section of adjoining country. Moreover, such high-voltage lines, if carried close to buildings, hamper the work of firemen in case of fire in the building. The object of these rules is so to direct this class of construction that no increase in fire hazard will result, while at the same time care has been taken to avoid restrictions which would unreasonably impede progress in electrical development.

It is fully understood that it is impossible to frame rules which will cover all conceivable cases that may arise in construction work of such an extended and varied nature, and it is advised that the Inspection Department having jurisdiction be freely consulted as to any modification of the rules in particular cases.)

a. Every reasonable precaution must be taken in arranging routes so as to avoid exposure to contacts with other electric circuits. On existing lines, where there is a liability to contact, the route should be changed by mutual agreement between the parties in interest wherever possible.

b. Such lines should not approach other pole lines nearer than a distance equal to the height of the taller pole line, and such lines should not be on the same poles with other wires, except that signalling wires used by the Company operating the high-pressure system, and which do not enter property other than that owned or occupied by such Company, may be carried over the same poles.

12 A. Constant-Potential Pole Lines—Continued.

c. Where such lines must necessarily be carried nearer to other pole lines than is specified in Section *b* above, or where they must necessarily be carried on the same poles with other wires, extra precautions to reduce the liability of a breakdown to a minimum must be taken, such as the use of wires of ample mechanical strength, widely spaced cross-arms, short spans, double or extra heavy cross-arms, extra heavy pins, insulators, and poles thoroughly supported. If carried on the same poles with other wires, the high-pressure wires must be carried at least three feet above the other wires.

d. Where such lines cross other lines, the poles of both lines must be of heavy and substantial construction.

Whenever it is feasible, end-insulator guards should be placed on the cross-arms of the upper line. If the high-pressure wires cross below the other lines, the wires of the upper line should be dead-ended at each end of the span to double-grooved, or to standard transposition insulators, and the line completed by loops.

One of the following forms of construction must then be adopted:—

1. The height and length of the cross-over span may be made such that the shortest distance between the lower cross-arms of the upper line and any wire of the lower line will be greater than the length of the cross-over span, so that a wire breaking near one of the upper pins would not be long enough to reach any wire of the lower line. The high-pressure wires

12 A. Constant-Potential Pole Lines—Continued.

should preferably be above the other wires.

2. A joint pole may be erected at the crossing point, the high-pressure wires being supported on this pole at least three feet above the other wires. Mechanical guards or supports must then be provided, so that in case of the breaking of any upper wire, it will be impossible for it to come into contact with any of the lower wires.

Such liability of contact may be prevented by the use of suspension wires, similar to those employed for suspending aerial telephone cables, which will prevent the high-pressure wires from falling, in case they break. The suspension wires should be supported on high-potential insulators, should have ample mechanical strength, and should be carried over the high-pressure wires for one span on each side of the joint pole, or where suspension wires are not desired guard wires may be carried above and below the lower wires for one span on each side of the joint pole, and so spread that a falling high-pressure wire would be held out of contact with the lower wires.

Such guard wires should be supported on high-potential insulators or should be grounded. When grounded, they must be of such size, and so connected and earthed, that they can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction must be such that the guard wires will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

3. Whenever neither of the above methods is feasible, a screen of wires should be interposed between the lines at the cross-over. This screen should be supported on high tension insulators or grounded and should be of such construction and strength as to prevent the upper wires from coming into contact with the lower ones.

12 A. Constant-Potential Pole Lines—Continued.

If the screen is grounded each wire of the screen must be of such size and so connected and earthed that it can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction must be such that the wires of screen will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

e. When it is necessary to carry such lines near buildings, they must be at such height and distance from the building as not to interfere with firemen in event of fire; therefore, if within 25 feet of a building, they must be carried at a height not less than that of the front cornice, and the height must be greater than that of the cornice, as the wires come nearer to the building in accordance with the following table:—

Distance of wire from building. Feet.	Elevation of wire above cornice of building. Feet.
25	0
20	2
15	4
10	6
5	8
2½	9

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

13. Transformers.

(*For construction rules, see No. 62.*)

(*See also Nos. 11, 13 A and 36.*)

Where transformers are to be connected to high-voltage circuits, it is necessary in many cases, for best protection to life and property, that the secondary system be permanently grounded, and provision should be made for it when the transformers are built.

13. Transformers—Continued.

a. Must not be placed inside of any building, excepting central stations and sub-stations, unless by special permission of the Inspection Department having jurisdiction.

An outside location is always preferable; first, because it keeps the high-voltage primary wires entirely out of the building, and second, for the reasons given in the note to No. 11 *a*.

b. Must not be attached to the outside walls of buildings, unless separated therefrom by substantial supports.

It is recommended that transformers be not attached to frame buildings when any other location is practicable

13 A. Grounding Low-Potential Circuits.

The grounding of low-potential circuits under the following regulations is only allowed when such circuits are so arranged that under normal conditions of service there will be no passage of current over the ground wire.

Direct-Current 3-Wire Systems.

a. Neutral wire may be grounded, and when grounded the following rules must be complied with:—

1. Must be grounded at the Central Station on a metal plate buried in coke beneath permanent moisture level, and also through all available underground water and gas-pipe systems.
2. In underground systems the neutral wire must also be grounded at each distributing box through the box.
3. In overhead systems the neutral wire must be grounded every 500 feet, as provided in Sections *c*, *e*, *f* and *g*.

13 A. Grounding Low-Potential Circuits—Continued.

Inspection Departments having jurisdiction may *require* grounding if they deem it necessary.

Two-wire direct-current systems having no accessible neutral point are not to be grounded.

Alternating-Current Secondary Systems.

b. Transformer secondaries of distributing systems should preferably be grounded, and when grounded, the following rules must be complied with:—

1. The grounding must be made at the neutral point or wire, whenever a neutral point or wire is accessible.
2. When no neutral point or wire is accessible, one side of the secondary circuit may be grounded, provided the maximum difference of potential between the grounded point and any other point in the circuit does not exceed 250 volts.
3. The ground connection must be at the transformer as provided in sections *d*, *e*, *f*, *g*, and when transformers feed systems with a neutral wire, the neutral wire must also be grounded at least every 250 feet for overhead systems, and every 500 feet for underground systems.

Inspection Departments having jurisdiction **may** *require* grounding if they deem it necessary.

Ground Connections.

c. The ground wire in direct-current 3-wire systems must not at Central Stations be smaller than the neutral wire and not smaller than No. 6 B. & S. gage elsewhere.

d. The ground wire in alternating-current systems must never be less than No. 6 B. & S. gage, and must always have equal carrying capacity to the secondary lead of the transformer, or the combined leads where transformers are connected in parallel.

13 A. Grounding Low-Potential Circuits—Continued.

On three-phase systems, the ground wire must have a carrying capacity equal to that of any one of the three mains.

e. The ground wire must be kept outside of buildings, but may be directly attached to the building or pole. The wire must be carried in as nearly a straight line as possible, and kinks, coils and sharp bends must be avoided.

f. The ground connection for Central Stations, transformer substations, and banks of transformers must be made through metal plates buried in coke below permanent moisture level, and connection should also be made to all available underground piping systems including the lead sheath of underground cables.

g. For individual transformers and building services the ground connection may be made as in Section *f*, or may be made to water or other piping systems running into the buildings. This connection may be made by carrying the ground wire into the cellar and connecting *on the street side* of meters, main cocks, etc., but connection must never be made to any lead pipes which form part of gas services.

In connecting a ground wire to a piping system, the wire should, if possible, be soldered into a brass plug and the plug forcibly screwed into a pipe-fitting, or, where the pipes are cast iron, into a hole tapped into the pipe itself. For large stations, where connecting to underground pipes with bell and spigot joints, it is well to connect to several lengths, as the pipe joints may be of rather high resistance. Where plugs cannot be used, the surface of the pipe may be filed or scraped bright, the wire wound around it, and a strong clamp put over the wire and firmly bolted together.

Where ground plates are used, a No. 16 Stubbs' gage copper plate, about three by six feet in size, with about two feet of crushed coke or charcoal, about pea size, both under and over it, would make a ground of sufficient capacity for a moderate-sized station, and would probably answer for the ordinary substation or bank of trans-

13 A. Grounding Low-Potential Circuits—Continued.

formers. For a large central station, a plate with considerably more area might be necessary, depending upon the other underground connections available. The ground wire should be riveted to the plate in a number of places, and soldered for its whole length. Perhaps even better than a copper plate is a cast-iron plate with projecting forks, the idea of the fork being to distribute the connection to the ground over a fairly broad area, and to give a large surface contact. The ground wire can probably best be connected to such a cast-iron plate by soldering it into brass plugs screwed into holes tapped in the plate. In all cases, the joint between the plate and the ground wire should be thoroughly protected against corrosion by painting it with waterproof paint or some equivalent.

INSIDE WORK.

(*Light, Power and Heat. For Signaling Systems, see Class E.*)

ALL SYSTEMS AND VOLTAGES.

GENERAL RULES.

14. Wires.

(*For special rules, see Nos. 18, 24, 35, 38 and 39.*)

a. Must not be of smaller size than No. 14 B. & S. gage, except as allowed under Nos. 24 *v* and 45 *b*.

b. Tie wires must have an insulation equal to that of the conductors they confine.

The use of some form of confining knob or insulator which will dispense with tie wires is recommended.

c. Must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered to insure preservation, and covered with an insulation equal to that on the conductors.

Stranded wires must be soldered before being fastened under clamps or binding screws, and whether stranded or solid, when they have a conductivity greater than that of No. 8 B. & S. gage they must be soldered into lugs for all terminal connections.

All joints must be soldered, even if made with some form of patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these rules.

d. Must be separated from contact with walls, floors, timbers or partitions through which they

14. Wires—Continued.

may pass by non-combustible, non-absorptive insulating tubes, such as glass or porcelain, except as provided in No. 24 *u*.

Bushings must be long enough to bush the entire length of the hole in one continuous piece, or else the hole must first be bushed by a continuous waterproof tube. This tube may be a conductor, such as iron pipe, but in that case an insulating bushing must be pushed into each end of it, extending far enough to keep the wire absolutely out of contact with the pipe.

e. Must be kept free from contact with gas, water or other metallic piping, or any other conductors or conducting material which they may cross, by some continuous and firmly fixed non-conductor, creating a permanent separation. Deviations from this rule may sometimes be allowed by special permission.

When one wire crosses another wire, the best and usual means of separating them is by means of a porcelain tube on one of them. The tube should be prevented from moving out of place, either by a cleat at each end, or by taping it securely to the wire.

The same method may be adopted where wires pass close to iron pipes, beams, etc., or, where the wires are above the pipes, as is generally the case, ample protection can frequently be secured by supporting the wires with a porcelain cleat placed as nearly above the pipe as possible.

This rule must not be construed as in any way modifying No. 24, Sections h and j.

f. Must be so placed in wet places that an air space will be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact with the pipe accidentally. Wires should be run over, rather than under, pipes upon which moisture is likely to gather or which, by leaking, might cause trouble on a circuit.

g. The installation of electrical conductors in wooden moulding or where supported on insulators in elevator shafts will not be approved, but conductors may be installed in such shafts if encased in approved metal conduits.

15. Underground Conductors.

a. Must be protected against moisture and mechanical injury where brought into a building, and all combustible material must be kept from the immediate vicinity.

b. Must not be so arranged as to shunt the current through a building around any catch-box.

c. Where underground service enters building through tubes, the tubes shall be tightly closed at outlets with asphaltum or other non-conductor, to prevent gases from entering the building through such channels.

d. No underground service from a subway to a building shall supply more than one building except by written permission from the Inspection Department having jurisdiction.

16. Table of Carrying Capacity of Wires.

a. The following table, showing the allowable carrying capacity of copper wires and cables of ninety-eight per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers, must be followed in placing interior conductors.

For insulated aluminum wire the safe carrying capacity is eighty-four per cent of that given in the following tables for copper wire with the same kind of insulation.

16. Table of Carrying Capacity of Wires—Continued.

B. & S. G.	TABLE A. Rubber Insulation. See No. 41. Amperes.	TABLE B. Other Insulations. See Nos. 42 to 44. Amperes.	Circular Mils.
18	3	5	1,624
16	6	8	2,583
14	12	16	4,107
12	17	23	6,530
10	24	32	10,380
8	33	46	16,510
6	46	65	26,250
5	54	77	33,100
4	65	92	41,740
3	76	110	52,630
2	90	131	66,370
1	107	156	83,690
0	127	185	105,500
00	150	220	133,100
000	177	262	167,800
0000	210	312	211,600
Circular Mils.			
200,000	200	300	
300,000	270	400	
400,000	330	500	
500,000	390	590	
600,000	450	680	
700,000	500	760	
800,000	550	840	
900,000	600	920	
1,000,000	650	1,000	
1,100,000	690	1,080	
1,200,000	730	1,150	
1,300,000	770	1,220	
1,400,000	810	1,290	
1,500,000	850	1,360	
1,600,000	890	1,430	
1,700,000	930	1,490	
1,800,000	970	1,550	
1,900,000	1,010	1,610	
2,000,000	1,050	1,670	

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the above tables.

The carrying capacity of Nos. 16 and 18, B. & S. gage wire is given, but no smaller than No. 14 is to be used, except as allowed under Nos. 24 *v* and 45 *b*.

17. Switches, Cut-outs, Circuit-Breakers, Etc.

(*For construction rules, see Nos. 51, 52 and 53.*)

a. Must, for constant potential circuits, unless otherwise provided (for exceptions, see No. 8 *c* and No. 22 *c*), be so arranged that the cut-outs will protect, and the opening of a switch or circuit-breaker will disconnect, all of the wires; that is, in a two-wire system the two wires, and in a three-wire system the three wires, must be protected by the cut-out and disconnected by the operation of the switch or circuit-breaker.

b. Must not be placed in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust or to flyings of combustible material.

In starch and candy factories, grain elevators, flouring mills, and buildings used for woodworking or other purposes which would cause the fittings to be exposed to dust and flyings of inflammable material, the cut-outs and switches should be placed in *approved* cabinets outside of the dust-rooms. If, however, it is necessary to locate them in the dust-rooms, the cabinets must be dust-proof and must be provided with self-closing doors.

c. Must, when exposed to dampness, either be enclosed in a waterproof box or mounted on porcelain knobs.

d. Time switches must be enclosed in an iron box or cabinet lined with fire resisting material.

If an iron box is used, the minimum thickness of the iron must be 0.128 of an inch (No. 8 B. & S. gage.)

If a cabinet is used, it must be lined with marble or slate at least three-eighths of an inch thick, or with iron not less than 0.128 of an inch thick. Box or cabinet must be so constructed that when switch operates blade shall clear the door by at least one inch.

CONSTANT-CURRENT SYSTEMS.

PRINCIPALLY SERIES ARC LIGHTING.

18. Wires.

(*See also Nos. 14, 15 and 16.*)

a. Must have an *approved* rubber insulating covering (see No 41).

b. Must be arranged to enter and leave the building through an *approved* double-contact service switch (see No. 51 *b*), mounted in a non-combustible case, kept free from moisture, and easy of access to police or firemen.

c. Must always be in plain sight, and never encased, except when *required* by the Inspection Department having jurisdiction.

d. Must be supported on glass or porcelain insulators, which separate the wire at least one inch from the surface wired over, and must be kept *rigidly* at least eight inches from each other, except within the structure of lamps, on hanger-boards or in cut-out boxes, or like places, where a less distance is necessary.

e. Must, on side walls, be protected from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than seven feet from the floor. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness. Instead of the running-boards, guard strips on

18. Wires—Continued.

each side of and close to the wires will be accepted. These strips to be not less than seven-eighths of an inch in thickness and at least as high as the insulators.

Except on joisted ceilings, a strip one half of an inch thick is not considered sufficiently stiff and strong. For spans of say eight or ten feet, where there is but little vibration, one-inch stock is generally sufficiently stiff; but where the span is longer than this or there is considerable vibration, still heavier stock should be used.

For general suggestions as to protecting wires on side walls, see notes under No. 24 *e*.

19. Series Arc Lamps.

(*For construction rules, see No. 57.*)

a. Must be carefully isolated from inflammable material.

b. Must be provided at all times with a glass globe surrounding the arc, and securely fastened upon a closed base. Broken or cracked globes must not be used.

c. Must be provided with a wire netting (having a mesh not exceeding one and one-fourth inches) around the globe, and an *approved* spark arrester (see No. 58), when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks of carbon or melted copper. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

Outside arc lamps must be suspended at least eight feet above sidewalks. Inside arc lamps must be placed out of reach or suitably protected.

Arc lamps, when used in places where they are exposed to flyings of easily inflammable material, should have the carbons enclosed completely in a tight globe in such manner as to avoid the necessity for spark arresters.

"Enclosed arc" lamps, having tight inner globes, may be used, and the requirements of Sections *b* and *c* above would, of course, not apply to them, except that a wire netting around the inner globe may in some cases be required if the outer globe is omitted.

19. Series Arc Lamps—Continued.

d. Where hanger-boards (see No. 56) are not used, lamps must be hung from insulating supports other than their conductors.

e. Lamps when arranged to be raised and lowered, either for carboning or other purposes, shall be connected up with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 B. & S. gage.

20. Incandescent Lamps in Series Circuits.

a. Must have the conductors installed as required in No. 18, and each lamp must be provided with an automatic cut-out.

b. Must have each lamp suspended from a hanger-board by means of rigid tube.

c. No electro-magnetic device for switches and no multiple-series or series-multiple system of lighting will be approved.

d. Must not under any circumstances be attached to gas fixtures.

CONSTANT-POTENTIAL SYSTEMS.

GENERAL RULES—ALL VOLTAGES.

21. Automatic Cut-outs (Fuses and Circuit-Breakers).

(*See No. 17, and for construction, Nos. 52 and 53.*)

Excepting on main switchboards, or where otherwise subject to expert supervision, circuit-breakers will not be accepted unless fuses are also provided.

a. Must be placed on all service wires, either overhead or underground, as near as possible to the point where they enter the building and inside the walls, and arranged to cut off the entire current from the building.

Where the switch required by No. 22 is inside the building, the cut-out required by this section must be placed so as to protect it.

In risks having private plants, the yard wires running from building to building are not generally considered as service wires, so that cut-outs would not be required where the wires enter buildings, provided that the next fuse back is small enough to properly protect the wires inside the building in question.

b. Must be placed at every point where a change is made in the size of wire [unless the cut-out in the larger wire will protect the smaller (see No. 16)].

c. Must be in plain sight, or enclosed in an *approved* cabinet (see No. 54), and readily accessible. They must not be placed in the canopies or shells of fixtures.

The ordinary porcelain link fuse cut-out will not be approved. Link fuses may be used only when mounted on slate or marble bases conforming to No. 52 and must be enclosed in dust-tight, fire-proofed cabinets, except

21. Automatic Cut-outs—Continued.

on switchboards located well away from combustible material, as in the ordinary engine and dynamo room and where these conditions will be maintained.

d. Must be so placed that no set of incandescent lamps requiring more than 660 watts, whether grouped on one fixture or on several fixtures or pendants, will be dependent upon one cut-out. Special permission may be given in writing by the Inspection Department having jurisdiction for departure from this rule in the case of large chandeliers, stage borders, and illuminated signs.

The above rule shall also apply to motors when more than one is dependent on a single cut-out.

The fuses in the branch cut-outs should not have a rated capacity greater than 6 amperes on 110 volt systems, and 3 amperes on 220 volt systems.

The idea is to have a small fuse to protect the lamp socket and the small wire used for fixtures, pendants, etc. It also lessens the chances of extinguishing a large number of lights if a short circuit occurs

On open work in large mills *approved* link fused rosettes may be used at a voltage of not over 125 and *approved* enclosed fused rosettes at a voltage of not over 250, the fuse in the rosettes not to exceed 3 amperes, and a fuse of over 25 amperes must not be used in the branch circuit.

All branches or taps from any three-wire system, which are directly connected to lamp sockets, must be run as two wire circuits, when the difference of potential between the two outside wires is over 250 volts.

e. The rated capacity of fuses must not exceed the allowable carrying capacity of the wire as given in No. 16. Circuit-breakers must not be set more than 30 per cent above the allowable carrying capacity of the wire, unless a fusible cut-out is also installed in the circuit.

In the arms of fixtures carrying a single socket a No. 18 B & S gage wire supplying only one socket will be considered as properly protected by a six ampere fuse

22. Switches.

(*See No. 17, and for construction, No. 61.*)

a. Must be placed on all service wires, either overhead or underground, in a readily accessible place, as near as possible to the point where the wires enter the building, and arranged to cut off the entire current.

Service cut-out and switch must be arranged to cut off current from all devices including meters.

In risks having private plants the yard wires running from building to building are not generally considered as service wires, so that switches would not be required in each building if there are other switches conveniently located on the mains or if the generators are near at hand.

b. Must always be placed in dry, accessible places, and be grouped as far as possible. Single-throw knife switches must be so placed that gravity will tend to open rather than close them. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal as preferred.

When possible, switches should be so wired that blades will be "dead" when switch is open.

If knife switches are used in rooms where combustible flyings would be likely to accumulate around them, they should be enclosed in dust-tight cabinets. (See note under No. 17 *b*.) Even in rooms where there are no combustible materials it is better to put all knife switches in cabinets, in order to lessen the danger of accidental short circuits being made across their exposed metal parts by careless workmen.

Up to 250 volts and thirty amperes, *approved* indicating snap switches are advised in preference to knife switches on lighting circuits about the workrooms.

c. Must not be single pole when the circuits which they control supply devices which require over 660 watts of energy, or when the difference of potential is over 300 volts.

22. Switches—Continued.

This of course does not apply to the grounded circuits of Street Railway systems. Three way switches are considered as single pole switches and must be wired so that only one pole of the circuit is carried to either switch.

d. Where flush switches or receptacles are used, whether with conduit systems or not, they must be enclosed in boxes constructed of iron or steel. No push buttons for bells, gas-lighting circuits, or the like shall be placed in the same wall plate with switches controlling electric light or power wiring.

This requires an *approved* box in addition to the porcelain enclosure of the switch or receptacle.

e. Where possible, at all switch or fixture outlets, a $\frac{1}{2}$-inch block must be fastened between studs or floor timbers flush with the back of lathing to hold tubes, and to support switches or fixtures. When this cannot be done, wooden base blocks, not less than $\frac{3}{4}$-inch in thickness, securely screwed to lathing, must be provided for switches, and also for fixtures which are not attached to gas pipes or conduit.

23. Electric Heaters.

It is often desirable to connect in multiple with the heaters and between the heater and the switch controlling same, an incandescent lamp of low candle power, as it shows at a glance whether or not the switch is open, and tends to prevent its being left closed through oversight. Inspection Departments having jurisdiction may require this provision to be carried out if they deem it necessary

a. Must be protected by a cut-out and controlled by indicating switches arranged as required for

23. Electric Heaters—Continued.

electric power devices employing the same current and potential.

b. Must never be concealed, but must at all times be in plain sight.

Special permission may be given in writing by the Inspection Department having jurisdiction for departure from this rule in certain cases.

c. Flexible conductors for smoothing irons and sad irons, and for all devices requiring over 250 watts, must comply with Rule 45, section *g*.

d. For portable heating devices the flexible conductors must be connected to an *approved* plug device, so arranged that the plug will pull out and open the circuit in case any abnormal strain is put on the flexible conductor. This device may be stationary, or it may be placed in the cord itself. The cable or cord must be attached to the heating apparatus in such manner that it will be protected from kinking, chafing, or like injury at or near the point of connection.

e. Smoothing irons, sad irons, and other heating appliances that are intended to be applied to inflammable articles, such as clothing, must conform to the above rules, so far as they apply. They must also be provided with an approved stand, on which they should be placed when not in use.

An approved automatic attachment which will cut off the current when the iron is not on the stand or in actual use, is desirable Inspection Departments having jurisdiction may require this provision to be carried out if they deem it advisable.

f. Stationary electric heating apparatus, such as radiators, ranges, plate warmers, etc., must be placed in a safe location, isolated from inflammable materials, and be treated as sources of heat.

23. Electric Heaters—Continued.

Devices of this description will often require a suitable heat resisting material placed between the device and its surroundings. Such protection may best be secured by installing two or more plates of tin or sheet iron with a one inch air space between or by alternate layers of sheet iron and asbestos with a similar air space

g. Must each be provided with name-plate, giving the maker's name and the normal capacity in volts and amperes.

LOW-POTENTIAL SYSTEMS.

550 VOLTS OR LESS.

Any circuit attached to any machine, or combination of machines, which develops a difference of potential between any two wires, of over ten volts and less than 550 volts, shall be considered as a low-potential circuit, and as coming under this class, unless an approved transforming device is used, which cuts the difference of potential down to ten volts or less. The primary circuit not to exceed a potential of 3,500 volts unless the primary wires are installed in accordance with the requirements as given in No. 12 A, or are underground.

For 550 volt motor equipments a margin of ten per cent above the 550 volt limit will be allowed at the generator or transformer.

Before pressure is raised above 300 volts on any previously existing system of wiring, the whole must be strictly brought up to all of the requirements of the rules at date.

24. Wires.

GENERAL RULES.

(See also Nos. 14, 15, and 16.)

***a.* Must be so arranged that under no circumstances will there be a difference of potential of over 300 volts between any bare metal parts in any distributing switch or cut-out cabinet, or equivalent center of distribution.**

This rule is not intended to prohibit the placing of switches or single pole cut-outs for motor systems of voltages above 300 in cabinets, but would require that the cabinets be divided by *approved* barriers so arranged that no one section shall contain more than one switch nor more than one single pole cut-out.

24. Wires—Continued.

b. Must not be laid in plaster, cement, or similar finish, and must never be fastened with staples.

c. Must not be fished for any great distance, and only in places where the inspector can satisfy himself that the rules have been complied with.

d. Twin wires must never be used, except in conduits, or where flexible conductors are necessary.

e. Must be protected on side walls from mechanical injury. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip, not less than one-half inch in thickness, and not less than three inches in width. Instead of the running-boards, guard strips on each side of and close to the wires will be accepted. These strips to be not less than seven-eighths of an inch in thickness, and at least as high as the insulators.

Suitable protection on side walls may be secured by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than five feet from the floor; or by an iron-armored or metal-sheathed insulating conduit sufficiently strong to withstand the strain to which it will be subjected, and with the ends protected by the lining or by special insulating bushings, so as to prevent the possibility of cutting the wire insulation; or by plain metal pipe, lined with *approved* flexible tubing, which must extend from the insulator next below the pipe to the one next above it.

If metal conduits or iron pipes are used to protect wires carrying alternating currents, the two or more wires of each circuit *must* be placed in the same conduit, as troublesome induction effects and heating of the pipe might otherwise result; and the insulation of *each* wire must be reinforced by *approved* flexible tubing extending from the insulator next below the pipe to the one next above it. This should also be done in direct-current wiring if there is any possibility of alternating current ever being used on the system.

For high-voltage work, or in damp places, the wooden boxing may be preferable, because of the precautions which would be necessary to secure proper insulation if the pipe were used. With these exceptions, however, iron pipe is considered preferable to the wooden box-

24. Wires—Continued.

ing, and its use is strongly urged. It is especially suitable for the protection of wires near belts, pulleys, etc.

f. When run in unfinished attics, will be considered as concealed and when run in close proximity to water tanks or pipes, will be considered as exposed to moisture.

In unfinished attics wires are considered as exposed to mechanical injury and must be run between or through floor joists and not on knobs on upper edge of joists.

SPECIAL RULES.

For Open Work.

In dry places.

g. Must have an *approved* rubber or "slow-burning weatherproof" insulation (see Nos. 41 and 42).

A "slow-burning weatherproof" covering is considered good enough where the wires are entirely on insulating supports. Its main object is to prevent the copper conductors from coming accidentally into contact with each other or anything else.

h. Must be rigidly supported on non-combustible, non-absorptive insulators, which will separate the wires from each other and from the surface wired over in accordance with the following table:—

Voltage.	Distance from Surface.	Distance between Wires.
0 to 300	½ inch	2½ inch
301 to 550	1 "	4 "

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports should be shortened. In buildings of mill construction, mains of No. 8 B. & S. gage wire or over, where not liable to be disturbed, may be separated about six inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

This rule will not be interpreted to forbid the placing of the neutral of an Edison three-wire system in the center of a three-wire cleat where the difference of potential between the outside wires is not over 300 volts, provided the outside wires are separated two and one-half inches.

24. Wires—Continued.

In damp places, or buildings specially subject to moisture or to acid or other fumes liable to injure the wires or their insulation.

i. Must have an *approved* insulating covering.

For protection against water, rubber insulation must be used. For protection against corrosive vapors, either weatherproof or rubber insulation must be used. (See Nos. 41 and 44.)

j. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one inch from the surface wired over, and must be kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

Rigid supporting requires under ordinary conditions, where wiring over flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports should be shortened. In buildings of mill construction, mains of No. 8 B. & S. gage wire or over, where not liable to be disturbed, may be separated about six inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

k. (Stricken out.)

For Moulding Work.

l. Must have an *approved* rubber insulating covering (see No. 41).

m. Must never be placed in moulding in concealed or damp places, or where the difference of potential between any two wires in the same moulding is over 300 volts.

As a rule, moulding should not be placed directly against a brick wall, as the wall is likely to "sweat" and thus introduce moisture back of the moulding.

For Conduit Work.

n. Must have an *approved* rubber insulating covering (see No. 47).

24. Wires—Continued.

o. Must not be drawn in until all mechanical work on the building has been, as far as possible, completed.

Conductors in vertical conduit risers must be supported within the conduit system in accordance with the following table:—

No. 14 to 0 every 100 feet.
No. 00 to 4-0 every 80 feet.
0000 to 350,000 C. M. every 60 feet.
350,000 C. M. to 500,000 C. M. every 50 feet.
500,000 C. M. to 750,000 C. M. every 40 feet.
750,000 C. M. every 35 feet.

A turn of 90 degrees in the conduit system will constitute a satisfactory support, as per above table.

The following methods of supporting cables are recommended:—

1. Junction boxes may be inserted in the conduit system at the required intervals, in which insulating supports of *approved* type must be installed and secured in a satisfactory manner so as to withstand the weight of the conductors attached thereto, the boxes to be provided with proper covers.
2. Cables may be supported in *approved* junction boxes on two or more insulating supports so placed that the conductors will be deflected at an angle of not less than 90 degrees, and carried a distance of not less than twice the diameter of the cable from its vertical position. Cables so suspended may be additionally secured to these insulators by tie wires.

Other methods, if used, must be approved by the Inspection Departments having jurisdiction.

24. Wires—Continued.

p. Must, for alternating systems, have the two or more wires of a circuit drawn in the same conduit.

It is advised that this be done for direct current systems also, so that they may be changed to alternating systems at any time, induction troubles preventing such a change if the wires are in separate conduits.

The same conduit must never contain circuits of different systems, but may contain two or more circuits of the same system.

For Concealed "Knob and Tube" Work.

q. Must have an *approved* rubber insulating covering (see No. 41).

r. Must be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least one inch from the surface wired over. Must be kept at least ten inches apart, and, when possible, should be run singly on separate timbers or studdings. Must be separated from contact with the walls, floor timbers and partitions through which they may pass by non-combustible, non-absorptive insulating tubes, such as glass or porcelain.

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports should be shortened.

Wires passing through timbers at the bottom of plastered partitions must be protected by an additional tube extending at least four inches above the timber.

s. When, in a concealed knob and tube system, it is impracticable to place any circuit on non-combustible supports of glass or porcelain, *approved* metal conduit or *approved* armored cable must be used (see No. 24 *t*), except that if the difference of potential between the wires is not over 300 volts, and if the wires are not exposed

24. Wires—Continued.

to moisture, they may be fished on the loop system if separately encased throughout in continuous lengths of *approved* flexible tubing.

t. Mixed concealed knob and tube work as provided for in No. 24 *s*, must comply with requirements of No. 24 to *p*, and No. 25, when conduit is used, and with requirements of No. 24 A, when armored cable is used.

u. Must at all outlets, except where conduit is used, be protected by *approved* flexible insulating tubing, extending in continuous lengths from the last porcelain support to at least one inch beyond the outlet. In the case of combination fixtures the tubes must extend at least flush with outer end of gas cap.

For Fixture Work.

v. Must have an *approved* rubber insulating covering (see No. 46), and be not less in size than No. 18 B. & S. gage.

See No. 46, *e*, fine print note, for exceptions to the use of rubber-covered wire.

w. Supply conductors, and especially the splices to fixture wires, must be kept clear of the grounded part of gas pipes, and, where shells or outlet boxes are used, they must be made sufficiently large to allow the fulfilment of this requirement.

x. Must, when fixtures are wired outside, be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture.

y. Under no circumstances must there be a difference of potential of more than 300 volts between wires contained in or attached to the same fixture.

24 A. Armored Cables.

(*For construction rules, see No. 48.*)

a. Must be continuous from outlet to outlet or

24 A. Armored Cables—Continued.

to junction boxes, and the armor of the cable must properly enter and be secured to all fittings.

In case of underground service connections and main runs, this involves running such armored cable continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be. (See No. 54.)

b. Must be equipped at every outlet with an *approved* outlet box or plate, as required in conduit work. (See No. 49 A.)

Outlet plates must not be used where it is practicable to install outlet boxes.

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted by special permission of the Inspection Department having jurisdiction, provided the armored cable is firmly and rigidly secured in place.

c. Must have the metal armor of the cable permanently and effectively grounded.

It is essential that the metal armor of such systems be joined so as to afford electrical conductivity sufficient to allow the largest fuse or circuit-breaker in the circuit to operate before a dangerous rise in temperature in the system can occur. Armor of cables and gas pipes must be securely fastened in metal outlet boxes so as to secure good electrical connection. Where boxes used for centers of distribution do not afford good electrical connection, the armor of the cables must be joined around them by suitable bond wires. Where sections of armored cable are installed without being fastened to the metal structure of buildings or grounded metal piping, they must be bonded together and joined to a permanent and efficient ground connection.

d. When installed in so-called fireproof buildings in course of construction or afterwards if concealed, or where it is exposed to the weather, or in damp places such as breweries, stables, etc., the cable must have a lead covering at least one thirty-second inch in thickness placed between the outer braid of the conductors and the steel armor.

e. Where entering junction boxes, and at all other outlets, etc., must be provided with *approved* terminal fittings which will protect the insulation of the conductors from abrasion, unless such junction or outlet boxes are specially designed and approved for use with the cable.

f. Junction boxes must always be installed in such a manner as to be accessible.

g. For alternating current systems must have the two or more conductors of the cable enclosed in one metal armor.

25. Interior Conduits.

(See also Nos. 24 n to p, and 49.)

The object of a tube or conduit is to facilitate the insertion or extraction of the conductors and to protect them from mechanical injury. Tubes or conduits are to be considered merely as raceways, and are not to be relied upon for insulation between wire and wire, or between the wire and the ground.

a. No conduit tube having an internal diameter of less than five eighths of an inch shall be used. Measurements to be taken inside of metal conduits.

b. Must be continuous from outlet to outlet or to junction boxes, and the conduit must properly enter, and be secured to all fittings.

In case of underground service connections and main runs, this involves running each conduit continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be (see No. 54).

c. Must be first installed as a complete conduit system, without the conductors.

d. Must be equipped at every outlet with an *approved* outlet box or plate (see No. 49 *l* to *o*).

Outlet plates must not be used where it is practicable to install outlet boxes.

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted by special

25. Interior Conduits—Continued.

permission of the Inspection Department having jurisdiction, providing the conduit ends are bushed and secured.

e. Metal conduits where they enter junction boxes, and at all other outlets, etc., must be provided with *approved* bushings fitted so as to protect wire from abrasion, except when such protection is obtained by the use of *approved* nipples, properly fitted in boxes or devices.

f. Must have the metal of the conduit permanently and effectually grounded.

It is essential that the metal of conduit systems be joined so as to afford electrical conductivity sufficient to allow the largest fuse or circuit breaker in the circuit to operate before a dangerous rise in temperature in the conduit system can occur. Conduits and gas pipes must be securely fastened in metal outlet boxes so as to secure good electrical connection. Where boxes used for centers of distribution do not afford good electrical connection, the conduits must be joined around them by suitable bond wires. Where sections of metal conduit are installed without being fastened to the metal structure of buildings or grounded metal piping, they must be bonded together and joined to a permanent and efficient ground connection.

g. Junction boxes must always be installed in such a manner as to be accessible.

h. All elbows or bends must be so made that the conduit or lining of same will not be injured. The radius of the curve of the inner edge of any elbow not to be less than three and one half inches. Must have not more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlets not being counted.

26. Fixtures.

(See also Nos. 22 e, 24 v to x.)

a. Must when supported from the gas piping or any grounded metal work of a building be insulated from such piping or metal work by means of

26. Fixtures—Continued.

approved insulating joints (see No. 50) **placed as** close as possible to the ceiling or walls.

Gas outlet pipes must be protected above the insulating joint by *approved* insulating tubing, and where outlet tubes are used they must be of sufficient length to extend below the insulating joint, and must be so secured that they will not be pushed back when the canopy is put in place.

Where canopies are placed against plaster walls or ceilings in fireproof buildings, or against metal walls or ceilings, or plaster walls or ceilings on metallic lathing in any class of buildings, they must be thoroughly and permanently insulated from such walls or ceilings.

b. Must have all burs, or fins, removed before the conductors are drawn into the fixture.

c. Must be tested for "contacts" between conductors and fixture, for "short circuits" and for ground connections before it is connected to its supply conductors.

27. Sockets.

(*For construction rules, see No. 55.*)

a. In rooms where inflammable gases may exist the incandescent lamp and socket must be enclosed in a vapor-tight globe, and supported on a pipe-hanger, wired with *approved* rubber-covered wire (see No. 41) soldered directly to the circuit.

Key sockets contain a switch (see No. 17 *b.*)

b. In damp or wet places, or over specially inflammable stuff, waterproof sockets must be used.

Waterproof sockets should be hung by separate, *stranded*, rubber-covered wires, not smaller than No. 14 B. & S. gage, which should preferably be twisted together when the pendant is over three feet long. These wires should be soldered direct to the circuit wires, but supported independently of them.

28. Flexible Cord.

a. Must have an *approved* insulation and covering (see No. 45).

b. Must not be used where the difference of potential between the two wires is over 300 volts.

28. Flexible Cord—Continued.

c. Must not be used as a support for clusters.

d. Must not be used except for pendants, wiring of fixtures, portable lamps or motors, and portable heating apparatus.

The practice of making the pendants unnecessarily long and then looping them up with cord adjusters is strongly advised against. It offers a temptation to carry about lamps which are intended to hang freely in the air, and the cord adjusters wear off the insulation very rapidly.

For all portable work, including those pendants which are liable to be moved about sufficiently to come in contact with surrounding objects, flexible wires and cables especially designed to withstand this severe service are on the market, and should be used. (See No. 45 *f*.)

The standard socket is threaded for one-eighth-inch pipe, and if it is properly bushed, the reinforced flexible cord will not go into it, but this style of cord may be used with sockets threaded for ⅜-inch pipe, and provided with substantial insulating bushings. The cable to be supported independently of the overhead circuit by a single cleat, and the two conductors then separated and soldered to the overhead wires.

The bulb of an incandescent lamp frequently becomes hot enough to ignite paper, cotton, and similar readily ignitible materials, and in order to prevent it from coming in contact with such materials, as well as to protect it from breakage, every portable lamp should be surrounded with a substantial wire guard.

e. Must not be used in show windows.

f. Must be protected by insulating bushings where the cord enters the socket.

g. Must be so suspended that the entire weight of the socket and lamp will be borne by some *approved* device under the bushing in the socket, and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws.

This is usually accomplished by knots in the cord inside the socket and rosette.

29. Arc Lamps on Constant-Potential Circuits.

a. Must have a cut-out (see No. 17 *a*) for each lamp or each series of lamps.

The branch conductors should have a carrying capacity about fifty per cent in excess of the normal current required by the lamp to provide for heavy current required when lamp is started or when carbons become stuck without overfusing the wires.

b. Must only be furnished with such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat. Incandescent lamps must not be used for this purpose.

c. Must be supplied with globes and protected by spark arresters and wire netting around the globe, as in the case of series arc lamps (see Nos. 19 and 58).

Outside arc lamps must be suspended at least eight feet above sidewalks. Inside arc lamps must be placed out of reach or suitably protected.

d. Lamps when arranged to be raised and lowered, either for carboning or other purposes, shall be connected up with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 B. & S. gage.

30. Economy Coils.

a. Economy and compensator coils for arc lamps must be mounted on non-combustible, non-absorptive insulating supports, such as glass or porcelain, allowing an air space of at least one inch between frame and support, and must in general be treated as sources of heat.

31. Decorative Lighting Systems.

a. Special permission may be given in writing by the Inspection Department having jurisdiction for the temporary installation of *approved* Systems of Decorative Lighting, provided the difference of potential between the wires of any circuit shall not be over 150 volts and also provided that no group of lamps requiring more than 1320 watts shall be dependent on one cut-out.

No "System of Decorative Lighting" to be allowed under this rule which is not listed in the Supplement to the National Electrical Code containing list of approved fittings.

b. Incandescent lamps connected in series must not be used for decorative purposes inside of buildings except by special permission in writing from the Inspection Department having jurisdiction.

32. Car Wiring and Equipment of Cars.

a. Protection of Car Body, etc.

1. Under side of car bodies to be protected by *approved* fire-resisting insulating material, not less than 1-8 inch in thickness, or by sheet iron or steel, not less than .04 inch in thickness, as specified in Section *a*, 2, 3, and 4. This protection to be provided over all electrical apparatus, such as motors with a capacity of over 75 H. P. each, resistances, contactors, lightning arresters, air brake motors, etc., and also where wires are run, except that protection may be omitted over wires designed to carry 25 amperes or less if they are encased in metal conduit.

2. At motors of over 75 H. P. each, fire-resisting material or sheet iron or steel extend to not less than 8 inches beyond all edges of openings in motors, and not less than 6 inches beyond motor leads on all sides.

32 Car Wiring and Equipment of Cars—Continued.

3. Over resistances, contactors, and lightning arresters, and other electrical apparatus, excepting when amply protected by their casing, fire-resisting material or sheet iron or steel to extend not less than 8 inches beyond all edges of the devices.

4. Over conductors, not encased in conduit, and conductors in conduit when designed to carry over 25 amperes, unless the conduit is so supported as to give not less than 1-2 inch clear air space between the conduit and the car, fire-resisting material or sheet iron or steel to extend at least 6 inches beyond conductors on either side.

The fire-resisting insulating material or sheet iron or steel may be omitted over cables made up of flameproof braided outer covering when surrounded by 1-8 inch flameproof covering, as called for by Section *i*, 4.

5. In all cases fireproof material or sheet iron or steel to have joints well fitted, to be securely fastened to the sills, floor timbers and cross braces, and to have the whole surface treated with a waterproof paint.

6. Cut-out and switch cabinets to be substantially made of hard wood. The entire inside of cabinet to be lined with not less than 1-8 inch fire-resisting insulating material which shall be securely fastened to the woodwork, and after the fire-resisting material is in place the inside of the cabinet shall be treated with a waterproof paint.

b. Wires, Cables, etc.

1. All conductors to be stranded, the allowable carrying capacity being determined by Table "A" of No. 16, except that motor, trolley and resistance leads shall not be less than No. 7 B. & S. gage, heater circuits not less than No. 12 B. & S. gage, and lighting and other auxiliary circuits not less than No. 14 B. & S. gage.

32. Car Wiring and Equipment of Cars—Continued.

The current used in determining the size of motor, trolley and resistance leads shall be a per cent of the full load current, based on one hour's run of the motor, as given by the following table:—

Size each motor.	Motor Leads.	Trolley Leads.	Resistance Leads.
75 H. P. or less	50%	40%	15%
Over 75 H. P.	45%	35%	15%

Fixture wire complying with No. 46 will be permitted for wiring *approved* clusters.

2. To have an insulation and braid as called for by No. 41 for wires carrying currents of the same potential.

3. When run in metal conduit, to be protected by an additional braid as called for by No. 47.

Where conductors are laid in conduit, not being drawn through, the additional braid will not be required.

4. When not in conduit, in *approved* moulding, or in cables surrounded by 1-8 inch flame-proof covering, must comply with the requirements of No. 41—except that tape may be substituted for braid—and be protected by an additional flame-proof braid, at least 1-32 inch in thickness, the outside being saturated with a preservative flame-proof compound.

This rule will be interpreted to include the leads from the motors.

5. Must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered and covered with an insulation equal to that on the conductors.

This rule will not be construed to apply to connection of leads at motors, plows, or third rail shoes.

32. Car Wiring and Equipment of Cars—Continued.

6. All connections of cables to cut-outs, switches and fittings, except those to controller connection boards, when designed to carry over 25 amperes, must be provided with lugs or terminals soldered to the cable, and securely fastened to the device, by bolts, screws, or by clamping; or, the end of the cable, after the insulation is removed, shall be dipped in solder and be fastened into the device by at least two set screws having check nuts.

All connections for conductors to fittings, etc., designed to carry less than 25 amperes, must be provided with turned-up lugs that will grip the conductor between the screw and the lug, the screws being provided with flat washers; or by block terminals having two set screws, and the end of the conductors must be dipped in solder. Soldering, in addition to the connection of the binding screws, is strongly recommended, and will be insisted on when above requirements are not complied with.

This rule will not be construed to apply to circuits where the maximum potential is not over 25 volts and current does not exceed 5 amperes.

c. Cut-outs, Circuit Breakers and Switches.

1. All cut-outs and switches having exposed live metal parts to be located in cabinets. Cut-outs and switches, not in iron boxes or in cabinets, shall be mounted on not less than 1-4 inch fire-resisting insulating material, which shall project at least 1-2 inch beyond all sides of the cut-out or switch.

2. Cut-outs to be of the *approved* cartridge or *approved* blow-out type.

3. All switches controlling circuits of over 5 ampere capacity shall be of *approved* single pole, quick break, or *approved* magnetic blow-out type.

32. Car Wiring and Equipment of Cars—Continued.

Switches controlling circuits of 5 ampere or less capacity may be of the *approved* single pole, double break, snap type.

4. Circuit breakers to be of *approved* type.

5. Circuits must not be fused above their safe carrying capacity.

6. A cut-out must be placed as near as possible to the current collector, so that the opening of the fuse in this cut-out will cut off all current from the car.

When cars are operated by metallic return circuits, with circuit breakers connected to both sides of the circuit, no fuses in addition to the circuit breakers will be required.

d. Conduit.

When from the nature of the case, or on account of the size of the conductors, the ordinary pipe and junction box construction is not permissible, a special form of conduit system may be used, provided the general requirements as given below are complied with.

1. Metal conduits, outlet and junction boxes to be constructed in accordance with No. 49, except that conduit for lighting circuits need not be over 5-16 inch internal diameter and 1-2 inch external diameter, and for heating and air motor circuits need not be over 3-8 inch internal diameter and 9-16 inch external diameter, and all conduits where exposed to dampness must be water tight.

2. Must be continuous between and be firmly secured into all outlet or junction boxes and fittings, making a thorough mechanical and electrical connection between same.

3. Metal conduits, where they enter all outlet or junction boxes and fittings, must be provided with *approved* bushings fitted so as to protect cables from abrasion.

4. Except as noted in Section *i*, 2, must have the metal of the conduit permanently and effectively grounded.

32. Car Wiring and Equipment of Cars—Continued.

5. Junction and outlet boxes must be installed in such a manner as to be accessible.

6. All conduits, outlets, or junction boxes and fittings to be firmly and substantially fastened to the framework of the car.

e. Moulding.

1. To consist of a backing and a capping and to be constructed of fire-resisting insulating material, except where circuits which they are designed to support are nominally not exposed to moisture, they may be constructed of hard wood.

2. When constructed of fire-resisting insulating material, the backing shall be not less than 1-4 inch in thickness and be of a width sufficient to extend not less than 1 inch beyond conductors at sides.

The capping, to be not less than 1-8 inch in thickness, shall cover and extend at least 3-4 inch beyond conductors on either side.

The joints in the moulding shall be mitred to fit close, the whole material being firmly secured in place by screws or nails, and treated on the inside and outside with a waterproof paint.

When fire-resisting moulding is used over surfaces already protected by 1-8 inch fire-resisting insulating material, no backing will be required.

3. Wooden mouldings must be so constructed as to thoroughly encase the wire and provide a thickness of not less than 3-8 inch at the sides and back of the conductors, the capping being not less than 3-16 inch in thickness. Must have both outside and inside two coats of waterproof paint.

The backing and the capping shall be secured in place by screws.

f. Lighting and Lighting Circuits.

1. Each outlet to be provided with an *ap-*

32. Car Wiring and Equipment of Cars—Continued.

proved porcelain receptacle, or an *approved* cluster. No lamp of over 32 candle power to be used.

2. Circuits to be run in *approved* metal conduit, or *approved* moulding.

3. When metal conduit is used, except for sign lights, all outlets to be provided with *approved* outlet boxes.

4. At outlet boxes, except where *approved* clusters are used, porcelain receptacles to be fastened to the inside of the box, and the metal cover to have an insulating bushing around opening for the lamp.

When *approved* clusters are used, the cluster shall be thoroughly insulated from the metal conduit, being mounted on blocks of hard wood or fire-resisting insulating material.

5. Where conductors are run in moulding the porcelain receptacles or cluster to be mounted on blocks of hard wood or of fireproof insulating material.

g. Heaters and Heating Circuits.

1. Heaters to be of *approved* type.

2. Panel heaters to be so constructed and located that when heaters are in place all current carrying parts will be at least 4 inches from all woodwork.

Heaters for cross seats to be so located that current carrying parts will be at least 6 inches below under side of seat, unless under side of seat is protected by not less than 1-4 inch fire-resisting insulating material, or .04 inch sheet metal with 1 inch air space over same, when the distance may be reduced to 3 inches.

3. Circuits to be run in *approved* metal conduit, or in *approved* moulding, or if the location of conductors is such as will permit an air space of not less than 2 inches on all sides except from the surface wired over, they may be supported on

32. Car Wiring and Equipment of Cars—Continued.

porcelain knobs or cleats, provided the knobs or cleats are mounted on not less than 1-4 inch fire-resisting insulating material extending at least 3 inches beyond conductors at either side, the supports raising the conductors not less than 1-2 inch from the surface wired over, and being not over 12 inches apart.

h. Air Pump Motor and Circuits.

1. Circuits to be run in *approved* metal conduit or in *approved* moulding, except that when run below the floor of the car they may be supported on porcelain knobs or cleats, provided the supports raise the conductor at least 1-2 inch from the surface wired over and are not over 12 inches apart.

2. Automatic control to be enclosed in an *approved* metal box. Air pump and motor, when enclosed, to be in *approved* metal box or a wooden box lined with metal of not less than 1-32 inch in thickness.

When conductors are run in metal conduit the boxes surrounding automatic control and air pump and motor may serve as outlet boxes.

i. Main Motor Circuits and Devices.

1. Conductors connecting between trolley stand and main cut-out or circuit breakers in hood, to be protected where wires enter car to prevent ingress of moisture.

2. Conductors connecting between third rail shoes on same truck, to be supported in an *approved* fire-resisting insulating moulding, or in *approved* iron conduit supported by soft rubber or other *approved* insulating cleats.

3. Conductors on the under side of the car, except as noted in Section *i*, 4, to be supported in accordance with one of the following methods:—

32. Car Wiring and Equipment of Cars—Continued.

a. To be run in *approved* metal conduit, junction boxes being provided where branches in conduit are made, and outlet boxes where conductors leave conduit.

b. To be run in *approved* fire-resisting insulating moulding.

c. To be supported by insulating cleats, the supports being not over 12 inches apart.

4. Conductors with flameproof braided outer covering, connecting between controllers at either end of car, or controllers and contactors, may be run as a cable, provided the cable where exposed to the weather is encased in a canvas hose or canvas tape, thoroughly taped or sewed at ends and where taps from the cable are made, and the hose or tape enters the controllers.

Conductors with or without flameproof braided outer covering connecting between controllers at either end of the car, or controllers and contactors, may be run as a cable, provided the cable throughout its entire length is surrounded by 1-8 inch flameproof covering, thoroughly taped or sewed at ends, or where taps from cable are made, and the flameproof covering enters the controllers.

Cables where run below floor of car may be supported by *approved* insulating straps or cleats. Where run above floor of car, to be in a metal conduit or wooden box painted on the inside with not less than two coats of flameproof paint, and where this box is so placed that it is exposed to water, as by washing of the car floor, attention should be given to making the box reasonably waterproof.

Canvas hose or tape, or flameproof material surrounding cables after conductors are in same, to have not less than two coats of waterproof insulating material.

5. Motors to be so drilled that, on double truck cars, connecting cables can leave motor on side nearest to king bolt.

32. Car Wiring and Equipment of Cars—Continued.

6. Resistances to be so located that there will be at least 6 inch air space between resistances proper and fire-resisting material of the car. To be mounted on iron supports, being insulated by non-combustible bushings or washers, or the iron supports shall have at least 2 inches of insulating surface between them and metal work of car, or the resistances may be mounted on hard wood bars, supported by iron stirrups, which shall have not less than 2 inches of insulating surface between foot of resistance and metal stirrup, the entire surface of the bar being covered with at least 1-8 inch fire-resisting insulating material.

The insulation of the conductor, for about 6 inches from terminal of the resistance, should be replaced, if any insulation is necessary, by a porcelain bushing or asbestos sleeve.

7. Controllers to be raised above platform of car by a not less than 1 inch hard wood block, the block being fitted and painted to prevent moisture working in between it and the platform.

j. Lightning Arresters.

1. To be preferably located to protect all auxiliary circuits in addition to main motor circuits.

2. The ground conductor shall be not less than No. 6 B. & S. gage, run with as few kinks and bends as possible, and be securely grounded.

k. General Rules.

1. When passing through floors, conductors or cables must be protected by *approved* insulating bushings, which shall fit the conductor or cable as closely as possible.

2. Moulding should never be concealed except where readily accessible. Conductors should never be tacked into moulding.

32. Car Wiring and Equipment of Cars—Continued.

3. Short bends in conductors should be avoided where possible.

4. Sharp edges in conduit or in moulding must be smoothed to prevent injury to conductors.

33. Car Houses.

a. The trolley wires must be securely supported on insulating hangers.

b. The trolley hangers must be placed at such a distance apart that, in case of a break in the trolley wire, contact cannot be made with the floor.

c. Must have a cut-out switch located at a proper place outside of the building, so that all trolley circuits in the building can be cut out at one point, and line circuit-breakers must be installed, so that when this cut-out switch is open the trolley wire will be dead at all points within 100 feet of the building. The current must be cut out of the building whenever the latter is not in use or the road is not in operation.

d. All lamps and stationary motors must be installed in such a way that one main switch can control the whole of each installation—lighting or power—independently of the main feeder switch. No portable incandescent lamps or twin wire will be allowed, except that portable incandescent lamps may be used in the pits, the circuit to be controlled by a switch placed outside of the pit, and the connections to be made by two *approved* rubber-covered flexible wires (see No. 41), properly protected against mechanical injury.

e. All wiring and apparatus must be installed in accordance with rules for constant-potential systems.

f. Must not have any system of feeder distribution centering in the building.

33. Car Houses—Continued.

g. The rails must be bonded at each joint with a conductor having a carrying capacity not less than that of a No. 2 B. & S. gage annealed copper wire.

h. Cars must not be left with the trolley in electrical connection with the trolley wire.

34. Lighting and Power from Railway Wires.

***a.* Must not be permitted, under any pretense, in the same circuit with trolley wires with a ground return, except in electric railway cars, electric car houses and their power stations; nor shall the same dynamo be used for both purposes.**

HIGH-POTENTIAL SYSTEMS.

550 TO 3,500 VOLTS.

Any circuit attached to any machine or combination of machines which develops a difference of potential, between any two wires, of over 550 volts and less than 3,500 volts, shall be considered as a high-potential circuit, and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 550 volts or less.

(See note following first paragraph under Low-Potential Systems, page 42.)

35. Wires.

(*See also Nos. 14, 15 and 16.*)

a. Must have an *approved* rubber-insulating covering (see No. 41).

b. Must be always in plain sight and never encased, except where required by the Inspection Department having jurisdiction.

35. Wires—Continued.

c. Must be rigidly supported on glass or porcelain insulators, which raise the wire at least one inch from the surface wired over, and must be kept about eight inches apart.

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least about every four and one-half feet. If the wires are unusually liable to be disturbed, the distance between supports should be shortened.

In buildings of mill construction, mains of No. 8 B. & S. gage or over, where not liable to be disturbed, may be separated about ten inches and run from timber to timber, not breaking around, and may be supported at each timber only.

d. Must be protected on side walls from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes) and extending not less than seven feet from the floor. When crossing floor timbers, in cellars, or in rooms where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

For general suggestions on protection, see note under No. 24 *e*. See also note under No 18 *e*.

36. Transformers. (When permitted inside buildings under No. 13.)

(*For construction rules, see No. 62.*)

(*See also Nos. 13 and 13 A.*)

Transformers must not be placed inside of buildings without special permission from the Inspection Department having jurisdiction.

a. Must be located as near as possible to the point at which the primary wires enter the building.

36. Transformers—Continued.

b. Must be placed in an enclosure constructed of fire-resisting material; the enclosure to be used only for this purpose, and to be kept securely locked, and access to the same allowed only to responsible parties.

c. Must be thoroughly insulated from the ground, or permanently and effectually grounded, and the enclosure in which they are placed must be practically air-tight, except that it must be thoroughly ventilated to the outdoor air, if possible, through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

37. Series Lamps.

a. No multiple series or series multiple system of lighting will be approved.

b. Must not, under any circumstances, be attached to gas fixtures.

EXTRA-HIGH-POTENTIAL SYSTEMS.

OVER 3,500 VOLTS.

Any circuit attached to any machine or combination of machines which develops a difference of potential, between any two wires, of over 3,500 volts, shall be considered as an extra-high-potential circuit, and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 3,500 volts or less.

38. Primary Wires.

a. Must not be brought into or over buildings, except power stations and sub-stations.

39. Secondary Wires.

a. Must be installed under rules for high-potential systems when their immediate primary wires carry a current at a potential of over 3,500 volts, unles the primary wires are installed in accordance with the requirements as given in No. 12 A or are entirely underground, within city, town and village limits.

CLASS D.

FITTINGS, MATERIALS AND DETAILS OF CONSTRUCTION.

(*Light, Power and Heat. For Signaling Systems, see Class E.*)

ALL SYSTEMS AND VOLTAGES.

The following rules are but a partial outline of requirements. Devices or materials which fulfil the conditions of these requirements and no more, will not necessarily be acceptable. All fittings and materials should be submitted for examination and test before being introduced for use.

Insulated Wires—Rules 40 to 48

40. General Rules.

a. Copper for insulated conductors must never vary in diameter so as to be more than two one-thousandths of an inch less than the specified size.

b. Wires and cables of all kinds designed to meet the following specifications must have a distinctive marking the entire length of the coil so that they may be readily identified in the field. They must also be plainly tagged or marked as follows :—

1. The maximum voltage at which the wire is designed to be used.
2. The words "National Electrical Code Standard."
3. Name of the manufacturing company and, if desired, trade name of the wire.
4. Month and year when manufactured.

41. Rubber-Covered Wire.

a. Copper for conductors must be thoroughly tinned.

Insulation for Voltages between 0 and 600.

b. Must be of rubber or other approved substance, and of a thickness not less than that given in the following table:—

B. & S. Gage.			Thickness.
18	to	16	1-32 inch.
15	to	8	3-64 "
7	to	2	1-16 "
1	to	0000	5-64 "
Circular Mils.			
250,000	to	500,000	3-32 "
500,000	to	1,000,000	7-64 "
Over		1,000,000	1-8 "

Measurements of insulating wall are to be made at the thinnest portion of the dielectric.

c. The completed coverings must show an insulation resistance of at least 100 megohms per mile during thirty days' immersion in water at seventy degrees Fahrenheit.

d. Each foot of the completed covering must show a dielectric strength sufficient to resist throughout five minutes the application of an electro-motive force proportionate to the thickness of insulation in accordance with the following table:—

THICKNESS in 64ths inches	BREAKDOWN TEST on 1 foot
1	3,000 Volts A. C.
2	6,000 " "
3	9,000 " "
4	11,000 " "
5	13,000 " "
6	15,000 " "
7	16,500 " "
8	18,000 " "
10	21,000 " "
12	23,500 " "
14	26,000 " "
16	28,000 " "

41. Rubber-Covered Wire—Continued.

The source of alternating electro-motive force shall be a transformer of at least one kilowatt capacity. The application of the electro-motive force shall first be made at 4,000 volts for five minutes and then the voltage increased by steps of not over 3,000 volts, each held for five minutes, until the rupture of the insulation occurs. The tests for dielectric strength shall be made on a sample of wire which has been immersed in water for seventy-two hours. One foot of the wire under test is to be submerged in a conducting liquid held in a metal trough, one of the transformer terminals being connected to the copper of the wire and the other to the metal of the trough.

Insulations for Voltages between 600 and 3,500.

e. The thickness of the insulating wall must not be less than that given in the following table:—

B. & S. Gage.			Thickness.			
14	to	1	.....3-32 inch.			
0	to	0000	.....3-32 "	covered by tape or braid.		
Circular Mils.						
250,000	to	500,000	.....3-32 "	"	"	"
Over		500,000	.....1-8 "	"	"	"

f. The requirements as to insulation and breakdown resistance for wires for low-potential systems shall apply, with the exception that an insulation resistance of not less than 300 megohms per mile shall be required.

Insulations for Voltages over 3,500.

g. Wire for arc-light circuits exceeding 3,500 volts potential must have an insulating wall not less than three-sixteenths of an inch in thickness, and shall withstand a breakdown test of at least 23,500 volts and have an insulation of at least 500 megohms per mile.

41. Rubber-Covered Wire—Continued.

The tests on this wire to be made under the same conditions as for low-potential wires.

Specifications for insulations for alternating currents exceeding 3,500 volts have been considered, but on account of the somewhat complex conditions in such work, it has so far been deemed inexpedient to specify general insulations for this use.

Protecting Braid.

h. All of the above insulations must be protected by a substantial braided covering, properly saturated with a preservative compound. This covering must be sufficiently strong to withstand all the abrasion likely to be met with in practice, and sufficiently elastic to permit all wires smaller than No. 7 B. & S. gage to be bent around a cylinder with twice the diameter of wire, without injury to the braid.

42. Slow-burning Weatherproof Wire.

a. The insulation must consist of two coatings, one to be fireproof in character and the other to be weatherproof. The fireproof coating must be on the outside and must comprise about 6-10 of the total thickness of the wall. The completed covering must be of a thickness not less than that given in the following table :—

B. & S. Gage.			Thickness.
14	to	8	3-64 inch.
7	to	2	1-16 "
1	to	0000	5-64 "
Circular Mils.			
250,000	to	500,000	3-32 "
500,000	to	1,000,000	7-64 "
Over		1,000,000	1-8 "

Measurements of insulating wall are to be made at the thinnest portion of the dielectric.

42. Slow-burning Weatherproof Wire—Continued.

This wire is not as burnable as "weatherproof," nor as subject to softening under heat. It is not suitable for outside work.

b. The fireproof coating shall be of the same kind as that required for "slow-burning wire," and must be finished with a hard, smooth surface if it is on the outside.

c. The weatherproof coating shall consist of a stout braid, applied and treated as required for "weatherproof wire," and must be thoroughly slicked down if it is on the outside.

43. Slow-burning Wire.

a. The insulation must consist of layers of cotton or other thread, all the interstices of which must be filled with the fireproofing compound, or of material having equivalent fire resisting and insulating properties. The outer layer must be braided and specially designed to withstand abrasion. The thickness of insulation must not be less than that required for "Slow-Burning Weatherproof Wire," and the outer surface must be finished smooth and hard.

The solid constituent of the fireproofing compound must not be susceptible to moisture, and must not burn even when ground in an oxidizable oil, making a compound which, while proof against fire and moisture, at the same time has considerable elasticity, and which when dry will suffer no change at a temperature of 250 deg. Fahr., and which will not burn at even a higher temperature.

"Slow-burning wire" must not be used without special permission from the Inspection Department having jurisdiction.

This is practically the old so-called "underwriters" insulation. It is especially useful in hot, dry places where ordinary insulations would perish, and where wires are bunched, as on the back of a large switchboard or in a wire tower, so that the accumulation of rubber or weatherproof insulations would result in an objectionably large mass of highly inflammable material. Its use is restricted, as its insulating qualities are not high and are diminished by moisture.

44. Weatherproof Wire.

a. The insulating covering shall consist of at least three braids, all of which must be thoroughly saturated with a dense moisture-proof compound, applied in such a manner as to drive any atmospheric moisture from the cotton braiding, thereby securing a covering to a great degree waterproof and of high insulating power. This compound must retain its elasticity at 0 deg. Fahr. and must not drip at 160 deg. Fahr. The thickness of insulation must not be less than that required for "slow-burning weatherproof wire," and the outer surface must be thoroughly slicked down.

This wire is for use outdoors, where moisture is certain and where fireproof qualities are not necessary.

45. Flexible Cord.

(*For installation rules, see No. 28.*)

a. Must, except as required for portable heating apparatus (see section *g*), be made of stranded copper conductors, each strand to be not larger than No. 26 or smaller than No. 30 B. & S. gage, and each stranded conductor must be covered by an *approved* insulation and protected from mechanical injury by a tough, braided outer covering.

For Pendant Lamps.

In this class is to be included all flexible cord which, under usual conditions, hangs freely in air, and which is not likely to be moved sufficiently to come in contact with surrounding objects.

It should be noted that pendant lamps provided with long cords, so that they can be carried about or hung over nails or on machinery, etc., are not included in this class, even though they are usually allowed to hang freely in air.

45. Flexible Cord—Continued.

b. Each stranded conductor must have a carrying capacity equivalent to not less than a No. 18 B. & S. gage wire.

c. The covering of each stranded conductor must be made up as follows:—

1. A tight, close wind of fine cotton.
2. The insulation proper, which shall be waterproof.
3. An outer cover of silk or cotton.

The wind of cotton tends to prevent a broken strand puncturing the insulation and causing a short circuit. It also keeps the rubber from corroding the copper.

d. The insulation must be solid, at least one thirty-second of an inch thick, and must show an insulation resistance of fifty megohms per mile throughout two weeks' immersion in water at 70 degrees Fahrenheit, and stand the tests prescribed for low-tension wires as far as they apply.

e. The outer protecting braiding should be so put on and sealed in place that when cut it will not fray out, and where cotton is used, it should be impregnated with a flameproof paint, which will not have an injurious effect on the insulation.

For Portables.

In this class is included all cord used on portable lamps, small portable motors, or any device which is liable to be carried about.

f. Flexible cord for portable use must meet all of the requirements for flexible cord "for pendant lamps," both as to construction and thickness of insulation, and in addition must have a tough braided cover over the whole. There must also be an extra layer of rubber between the outer cover and the flexible cord, and in moist places the outer cover must be saturated with a moisture-proof

45. Flexible Cord—Continued.

compound, thoroughly slicked down, as required for "weatherproof wire" in No. 44. In offices, dwellings or in similar places where the appearance is an essential feature, a silk cover may be substituted for the weatherproof braid.

For Portable Heating Apparatus.

(Applies to all smoothing and sad irons and to any other device requiring over 250 watts.)

g. Must be made up as follows:—

1. Conductors must be of braided copper, each strand not to be larger than No. 30 or smaller than No. 36 B. &. S. gage.

When conductors have a greater carrying capacity than No. 12 B. & S. gage they may be braided or stranded with each strand as large as No. 28 B. & S. gage. If stranded there must be a tight close wind of cotton between the conductor and the insulation.

2. An insulating covering of rubber or other *approved* material not less than one sixty-fourth inch in thickness.
3. A braided covering not less than one thirty-second inch thick, composed of best quality long fibre asbestos, containing not over 5 per cent of vegetable fibre.
4. The several conductors comprising the cord to be enclosed by an outer reinforcing covering not less than one sixty-fourth inch thick, especially designed to resist abrasion, and so treated as to prevent the cover from fraying.

46. Fixture Wire.

(*For installation rules, see No. 24 v to y.*)

a. May be made of solid or stranded conductors with no strands smaller than No. 30 B. & S. gage

46. Fixture Wire—Continued.

and must have a carrying capacity not less than that of a No. 18 B. & S. gage wire.

b. Solid conductors must be thoroughly tinned. If a stranded conductor is used, it must be covered by a tight, close wind of fine cotton.

c. Must have a solid rubber insulation of a thickness not less than one thirty-second of an inch for Nos. 18 to 16 B. & S. gage, and three sixty-fourths of an inch for Nos. 14 to 8 B. & S. gage, except that in arms of fixtures not exceeding twenty-four inches in length and used to supply not more than one sixteen-candle-power lamp or its equivalent, which are so constructed as to render impracticable the use of a wire with one thirty-second of an inch thickness of rubber insulation, a thickness of one sixty-fourth of an inch will be permitted.

d. Must be protected with a covering at least one sixty-fourth of an inch in thickness, sufficiently tenacious to withstand the abrasion of being pulled into the fixture, and sufficiently elastic to permit the wire to be bent around a cylinder with twice the diameter of the wire without injury to the braid.

e. Must sucessfully withstand the tests specified in Nos. 41 *c* and 41 *d*.

In wiring certain designs of show case fixtures, ceiling bulls-eyes and similar appliances in which the wiring is exposed to temperatures in excess of 120 degrees Fahrenheidt, from the heat of the lamps, slow-burning wire may be used (see No. 44.) All such forms of fixtures must be submitted for examination test and approved before being introduced for use.

47. Conduit Wire.

(*For installation rules, see No. 24 n to p.*)

a. Single wire for lined conduits must comply

47. Conduit Wire—Continued.

with the requirements of No. 41. For unlined conduits it must comply with the same requirements,—except that tape may be substituted for braid,—and in addition there must be a second outer fibrous covering, at least one thirty-second of an inch in thickness and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

b. For twin or duplex wires in lined conduit, each conductor must comply with the requirements of No. 41,—except that tape may be substituted for braid on the separate conductors,—and must have a substantial braid covering the whole. For unlined conduit, each conductor must comply with requirements of No. 41,—except that tape may be substituted for braid,—and in addition must have a braid covering the whole, at least one thirty-second of an inch in thickness and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

c. For concentric wire, the inner conductor must comply with the requirements of No. 41,—except that tape may be substituted for braid,—and there must be outside of the outer conductor the same insulation as on the inner, the whole to be covered with a substantial braid, which for unlined conduits must be at least one thirty-second of an inch in thickness, and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

The braid or tape required around each conductor in duplex, twin and concentric cables is to hold the rubber insulation in place and prevent jamming and flattening.

48. Armored Cable.

a. The armor of such cables must have at least as great strength to resist penetration of nails, etc., as is required for metal conduits (see No. 49 *b*), and its thickness must not be less than that specified in the following table:—

48. Armored Cable—Continued.

Nominal Internal Diameter. Inches.	Actual Internal Diameter. Inches.	Actual External Diameter. Inches.	Thickness of Wall. Inches.
⅜	.27	.40	.06
½	.36	.54	.08
⅝	.49	.67	.09
¾	.62	.84	.10
⅞	.82	1.05	.11
1	1.04	1.31	.13
1¼	1.38	1.66	.14
1½	1.61	1.90	.14
2	2.06	2.37	.15
2½	2.46	2.87	.20
3	3.06	3.50	.21
3½	3.54	4.00	.22
4	4.02	4.50	.23
4½	4.50	5.00	.24
5	5.04	5.56	.25
6	6.06	6.62	.28

An allowance of two one-hundredths of an inch for variation in manufacturing and loss of thickness by cleaning will be permitted.

b. The conductors in same, single wire or twin conductors, must have an insulating covering as required by No. 41; if any filler is used to secure a round exterior, it must be impregnated with a moisture repellent, and the whole bunch of conductors and fillers must have a separate exterior covering.

49. Interior Conduits.

(For installation rules, see Nos. 24 n to p and 25.)

a. Each length of conduit, whether lined or unlined, must have the maker's name or initials stamped in the metal or attached thereto in a satisfactory manner, so that inspectors can readily see the same.

The use of paper stickers or tags cannot be considered satisfactory methods of marking, as they are readily loosened and lost off in the ordinary handling of the conduit.

49. Interior Conduits—Continued.

Metal Conduits with Lining of Insulating Material.

b. The metal covering or pipe must be at least as strong as the ordinary commercial forms of gas pipe of the same size, and its thickness must be not less than that of standard gas pipe as specified in the table given in No. 48.

c. Must not be seriously affected externally by burning out a wire inside the tube when the iron pipe is connected to one side of the circuit.

d. Must have the insulating lining firmly secured to the pipe.

e. The insulating lining must not crack or break when a length of the conduit is uniformly bent at temperature of 212 degrees Fahrenheit to an angle of ninety degrees, with a curve having a radius of fifteen inches, for pipes of one inch and less, and fifteen times the diameter of pipe for larger sizes.

f. The insulating lining must not soften injuriously at a temperature below 212 degrees Fahrenheit and must leave water in which it is boiled practically neutral.

g. The insulating lining must be at least one thirty-second of an inch in thickness. The materials of which it is composed must be of such a nature as will not have a deteriorating effect on the insulation of the conductor, and be sufficiently tough and tenacious to withstand the abrasion test of drawing long lengths of conductors in and out of same.

h. The insulating lining must not be mechanically weak after three days' submersion in water, and when removed from the pipe entire, must not absorb more than ten per cent of its weight of water during 100 hours of submersion.

i. All elbows or bends must be so made that the conduit or lining of same will not be injured.

49. Interior Conduits—Continued.

The radius of the curve of the inner edge of any elbow must not be less than three and one-half inches.

Unlined Metal Conduits.

j. Plain iron or steel pipes of thicknesses and strengths equal to those specified for lined conduits in No. 49 *b* may be used as conduits, provided their interior surfaces are smooth and free from burs. In order to prevent oxidization, the pipe must be galvanized, or the interior surfaces coated or enameled with some substance which will not soften so as to become sticky and prevent the wire from being withdrawn from the pipe.

k. All elbows or bends must be so made that the conduit will not be injured. The radius of the curve of the inner edge of any elbow not to be less than three and one-half inches.

49 A. Switch and Outlet Boxes.

a. Must be of pressed steel having a wall thickness not less than .081 inch (No. 12 B. & S. gage) or of cast metal having a wall thickness not less than .128 inch (No. 8 B. & S. gage).

b. Must be well galvanized, enameled or otherwise properly coated, inside and out, to prevent oxidation.

c. Inlet holes must be effectually closed, when not in use, by metal which will afford protection substantially equivalent to that of the walls of the box.

d. Must be plainly marked, where it may readily be seen when installed, with the name or trade mark of the manufacturer.

e. Must be arranged to secure in position the conduit or flexible tubing protecting the wire.

This rule will be complied with if the conduit or

49 A. Switch and Outlet Boxes—Continued.

tubing is firmly secured in position by means of some *approved* device which may or may not be a part of the box.

f. Boxes used with lined conduit must comply with the foregoing requirements, and in addition must have a tough and tenacious insulating lining at least 1-32 inch thick, firmly secured in position.

g. Switch boxes must completely enclose the switch on sides and back, and must provide a thoroughly substantial support for it. The retaining screws for the box must not be used to secure the switch in position.

50. Wooden Mouldings.

(*For wiring rules, see No. 24, l and m.*)

a. Must have, both outside and inside, at least two coats of waterproof material, or be impregnated with a moisture repellent.

b. Must be made in two pieces, a backing and a capping, and must afford suitable protection from abrasion. Must be so constructed as to thoroughly encase the wire, be provided with a tongue not less than 1-2 inch in thickness between the conductors, and have exterior walls which under grooves shall not be less than 3-8 inch in thickness, and on the sides not less than 1-4 inch in thickness.

It is recommended that only hard-wood moulding be used.

50 A. Tubes and Bushings.

a. **Construction.**—Must be made straight and free from checks or rough projections, with ends smooth and rounded to faciliate the drawing in of the wire and prevent abrasion of its covering.

50 A. Tubes and Bushings—Continued.

b. **Material and Test.**—Must be made of non-combustible insulating material, which, when broken and submerged for 100 hours in pure water at 70 degrees Fahrenheit, will not absorb over one half of one per cent of its weight.

c. **Marking.**—Must have the name, initials, or trade mark of the manufacturer stamped in the ware.

d. **Sizes.**—Dimensions of walls and heads must be at least as great as those given in the following table:—

Diameter of Hole.	External Diameter.	Thickness of Wall.	External Diameter of Head.	Length of Head.
$\frac{5}{16}$ in.	$1\frac{9}{16}$ in.	$\frac{1}{8}$ in.	$1\frac{13}{16}$ in.	$\frac{1}{2}$ in.
$\frac{3}{8}$	$1\frac{11}{16}$	$\frac{5}{32}$	$1\frac{15}{16}$	$\frac{1}{2}$
$\frac{1}{2}$	$1\frac{13}{16}$	$\frac{5}{32}$	$1\frac{3}{16}$	$\frac{1}{2}$
$\frac{5}{8}$	$1\frac{15}{16}$	$\frac{5}{32}$	$1\frac{5}{16}$	$\frac{1}{2}$
$\frac{3}{4}$	$1\frac{3}{16}$	$\frac{7}{32}$	$1\frac{11}{16}$	$\frac{5}{8}$
1	$1\frac{7}{16}$	$\frac{7}{32}$	$1\frac{5}{16}$	$\frac{5}{8}$
$1\frac{1}{4}$	$1\frac{13}{16}$	$\frac{9}{32}$	$2\frac{5}{16}$	$\frac{5}{8}$
$1\frac{1}{2}$	$2\frac{3}{16}$	$\frac{11}{32}$	$2\frac{11}{16}$	$\frac{3}{4}$
$1\frac{3}{4}$	$2\frac{9}{16}$	$\frac{13}{32}$	$3\frac{1}{16}$	$\frac{3}{4}$
2	$2\frac{15}{16}$	$\frac{15}{32}$	$3\frac{7}{16}$	$\frac{3}{4}$
$2\frac{1}{4}$	$3\frac{5}{16}$	$\frac{17}{32}$	$3\frac{13}{16}$	1
$2\frac{1}{2}$	$3\frac{11}{16}$	$\frac{19}{32}$	$4\frac{3}{16}$	1

An allowance of one sixty-fourth of an inch for variation in manufacturing will be permitted, except in the thickness of the wall.

50 B. Cleats.

a. **Construction.**—Must hold the wire firmly in place without injury to its covering.

Sharp edges which may cut the wire should be avoided.

50 B. Cleats—Continued.

b. **Supports.**—Bearing points on the surface must be made by ridges or rings about the holes for supporting screws, in order to avoid cracking and breaking when screwed tight.

c. **Material and Test.**—Must be made of non-combustible insulating material, which, when broken and submerged for 100 hours in pure water at 70 degrees Fahrenheit, will not absorb over one half of one per cent of its weight.

d. **Marking.**—Must have the name, initials, or trade mark of the manufacturer stamped in the ware.

e. **Sizes.**—Must conform to the spacings given in the following table:—

Voltage.	Distance from Wire to Surface.	Distance between Wires.
0-300	½ inch.	2½ inches.

This rule will not be interpreted to forbid the placing of the neutral of an Edison three-wire system in the center of a three-wire cleat where the difference of potential between the outside wires is not over 300 volts, provided the outside wires are separated two and one-half inches.

50 C. Flexible Tubing.

(NOTE.—The specifications for Flexible Tubing have been referred to a sub-committee for further consideration and report at the general meeting in December, 1905.)

51. Switches.

(*For installation rules, see Nos. 17 and 22.*)

General Rules.

a. Must, when used for service switches, indicate, on inspection, whether the current be "on" or "off."

51. Switches—Continued.

b. Must, for constant-current systems, close the main circuit and disconnect the branch wires when turned "off"; must be so constructed that they shall be automatic in action, not stopping between points when started, and must prevent an arc between the points under all circumstances. They must indicate whether the current be "on" or "off."

Knife Switches.

Knife switches must be made to comply with the following specifications, except in those few cases where peculiar design allows the switch to fulfill the general requirements in some other way, and where it can successfully withstand the test of Section *i*. In such cases, the switch should be submitted for special examination before being used.

c. **Base.**—Must be mounted on non-combustible, non-absorptive, insulating bases, such as slate or porcelain. Bases with an area of over twenty-five square inches must have at least four supporting screws. Holes for the supporting screws must be so located or countersunk that there will be at least one half of an inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part, and in all cases when between parts of opposite polarity must be countersunk.

d. Mounting.—Pieces carrying the contact jaws and hinge clips must be secured to the base by at least two screws, or else made with a square shoulder, or provided with dowel-pins, to prevent possible turnings, and the nuts or screw-heads on the under side of the base must be countersunk not less than one eighth inch and covered with a waterproof compound which will not melt below 150 degrees Fahrenheit.

e. Hinges.—Hinges of knife switches must not be used to carry current unless they are equipped

51. Switches—Continued.

with spring washers, held by lock-nuts or pins, or their equivalent, so arranged that a firm and secure connection will be maintained at all positions of the switch blades.

Spring washers must be of sufficient strength to take up any wear in the hinge and maintain a good contact at all times.

f. **Metal.**—All switches must have ample metal for stiffness and to prevent rise in temperature of any part of over fifty degrees Fahrenheit at full load, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about one square inch for each seventy-five amperes; the whole device must be mechanically well made throughout.

g. **Cross-Bars.**—All cross-bars less than three inches in length must be made of insulating material. Bars of three inches and over, which are made of metal to insure greater mechanical strength, must be sufficiently separated from tne jaws of the switch to prevent arcs following from the contacts to the bar on the opening of the switch under any circumstances. Metal bars should preferably be covered with insulating material.

To prevent possible turning or twisting the cross-bar must be secured to each blade by two screws, or the joints made with square shoulders or provided with dowel-pins.

h. **Connections.**—Switches for currents of over thirty amperes must be equipped with lugs, firmly screwed or bolted to the switch, and into which the conducting wires shall be soldered. For the smaller sized switches simple clamps can be employed, provided they are heavy enough to stand considerable hard usage.

51. Switches—Continued.

Where lugs are not provided, a rugged double-V groove clamp is advised. A set screw gives a contact at only one point, is more likely to become loosened, and is almost sure to cut into the wire. For the smaller sizes, a screw and washer connection with turned up lugs on the switch terminal gives a satisfactory contact.

i. **Test.**—Must operate successfully at 50 per cent overload in amperes and 25 per cent excess voltage, under the most severe conditions with which they are liable to meet in practice.

This test is designed to give a reasonable margin between the ordinary rating of the switch and the breaking-down point, thus securing a switch which can always safely handle its normal load. Moreover, there is enough leeway so that a moderate amount of overloading would not injure the switch.

j. **Marking.**—Must be plainly marked where it will be visible, when the switch is installed, with the name of the maker and the current and the voltage for which the switch is designed.

k. **Spacings.**—Spacings must be at least as great as those given in the following table. The spacings specified are correct for switches to be used on direct-current systems, and can therefore be safely followed in devices designed for alternating currents.

51. Switches—Continued.

125 VOLTS OR LESS:	Minimum Separation of Nearest Metal Parts of Opposite Polarity.	Minimum Break-Distance.
For Switchboards and Panel Boards:—		
10 amperes or less	$\frac{3}{4}$ inch	$\frac{1}{2}$ inch.
11-30 amperes	1 "	$\frac{3}{4}$ "
31-50 "	$1\frac{1}{4}$ "	1 "
For Individual Switches:—		
10 amperes or less	1 inch	$\frac{3}{4}$ inch.
11-30 amperes	$1\frac{1}{4}$ "	1 "
31-100 "	$1\frac{1}{2}$ "	$1\frac{1}{4}$ "
101-300 "	$2\frac{1}{4}$ "	2 "
301-600 "	$2\frac{3}{4}$ "	$2\frac{1}{2}$ "
601-1000 "	3 "	$2\frac{3}{4}$ "
126 to 250 VOLTS:		
For all Switches:—		
10 amperes or less	$1\frac{1}{2}$ inch	$1\frac{1}{2}$ inch.
11-30 amperes	$1\frac{3}{4}$ "	$1\frac{1}{2}$ "
31-100 "	$2\frac{1}{4}$ "	2 "
101-300 "	$2\frac{1}{2}$ "	$2\frac{1}{4}$ "
301-600 "	$2\frac{3}{4}$ "	$2\frac{1}{2}$ "
601-1000 "	3 "	$2\frac{3}{4}$ "

For 100 ampere switches and larger, the above spacings for 250 volts direct current are also approved for 500 volts alternating current. Switches with these spacings intended for use on alternating-current systems with voltage above 250 volts must be stamped with the voltage for which they are designed, followed by the letters "A, C."

251 to 600 VOLTS:		
For all Switches:—		
10 amperes or less	$3\frac{1}{2}$ inch	3 inch.
11-35 amperes	4 "	$3\frac{1}{2}$ "
36-100 "	$4\frac{1}{2}$ "	4 "

Auxiliary breaks or the equivalent are recommended for switches designed for over 300 volts and less than 100 amperes, and will be required on switches designed *for use in breaking currents* greater than 100 amperes at a pressure of more than 300 volts.

For three-wire Edison systems the separations and break distances for plain three-pole knife switches must not be less than those required in the above table for switches designed for the voltage between the neutral and outside wires.

51. Switches—Continued.

Snap Switches.

Flush, push-button, door, fixture, and other snap switches used on constant-potential systems, must be constructed in accordance with the following specifications.

l. **Base.**—Current-carrying parts must be mounted on non-combustible, non-absorptive insulating bases, such as slate or porcelain, and the holes for supporting screws should be countersunk not less than one eighth of an inch. There must in no case be less than three sixty-fourths of an inch space between supporting screws and current-carrying parts.

Sub-bases of non-combustible, non-absorptive insulating material, which will separate the wires at least one half of an inch from the surface wired over, must be furnished with all snap switches used in exposed knob or cleat work.

m. **Mounting.**—Pieces carrying contact jaws must be secured to the base by at least two screws, or else made with a square shoulder, or provided with dowel-pins or otherwise arranged, to prevent possible turnings; and the nuts or screw heads on the under side of the base must be countersunk not less than one-eighth inch, and covered with a waterproof compound which will not melt below 150 degrees Fahrenheit.

n. **Metal.**—All switches must have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load, the contacts being arranged so that a thoroughly good bearing at every point is obtained. The whole device must be mechanically well made throughout.

In order to meet the above requirements on temperature rise without causing excessive friction and wear on current-carrying parts, contact surfaces of from 0.1 to 0.15 square inch for each 10 amperes will be required, depending upon the metal used and the form of construction adopted.

51. Switches—Continued.

o. **Insulating Material.**—Any material used for insulating current-carrying parts must retain its insulating and mechanical strength when subject to continued use, and must not soften at a temperature of 212 degrees Fahrenheit.

p. **Binding Posts.**—Binding posts must be substantially made, and the screws must be of such size that the threads will not strip when set up tight.

q. **Covers.**—Covers made of conducting material, except face plates for flush switches, must be lined on sides and top with insulating, tough and tenacious material at least one thirty-second inch in thickness, firmly secured so that it will not fall out with ordinary handling. The side lining must extend slightly beyond the lower edge of the cover.

r. **Handle or Button.**—The handle or button or any exposed parts must not be in electrical connection with the circuit.

s. **Test.**—Must "make" and "break" with a quick snap, and must not stop when motion has once been imparted by the button or handle.

Must operate successfully at 50 per cent overload in amperes and 25 per cent excess voltage, under the most severe conditions with which they are liable to meet in practice.

When slow y turned "on and off" at the rate of about two or three times per minute, while carrying the rated current, must "make and break" the circuit six thousand times before failing.

t. **Marking.**—Must be plainly marked, where it may be readily seen after the device is installed, with the name or trade mark of the maker and the current and voltage for which the switch is designed.

51. Switches—Continued.

On flush switches these markings may be placed on the back of the face plate or on the sub-plate. On other types they must be placed on the *front* of the cap, cover, or plate.

Switches which indicate whether the current is "on" or "off" are recommended.

52. Cut-Outs and Circuit-Breakers.

(*For installation rules, see Nos. 17 and 21.*)

These requirements do not apply to rosettes, attachment plugs, car lighting, cut-outs and protective devices for signaling systems.

General Rules.

a. Must be supported on bases of non-combustible, non-absorptive insulating material.

b. Cut-outs must be of plug or cartridge type, when not arranged in *approved* cabinets, so as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

c. Cut-outs must operate successfully on short-circuits, under the most severe conditions with which they are liable to meet in practice, at twenty-five per cent above their rated voltage, and for link fuse cut-outs with fuses rated at fifty per cent above the current for which the cut-out is designed, and for enclosed fuse cut-outs with the largest fuses for which the cut-out is designed.

With link fuse cut-outs there is always the possibility of a larger fuse being put into the cut-out than it was designed for, which is not true of enclosed fuse cut-outs classified as required under No. 52, *g*. Again, the voltage in most plants can, under some conditions, rise considerably above the normal. The need of some margin, as a factor of safety to prevent the cut-outs from being ruined in ordinary service, is therefore evident.

The most severe service which can be required of a cut-out in practice is to open a "dead short-circuit" with only one fuse blowing, and it is with these conditions that all tests should be made. (See Section *j*.)

52. Cut-Outs and Circuit-Breakers—Continued.

d. Circuit-breakers must operate successfully on short-circuits, under the most severe conditions with which they are liable to meet in practice, at twenty-five per cent above their rated voltage and with the circuit breaker set at the highest possible opening point.
For the same reason as in Section *c.*

e. Must be plainly marked where it will always be visible, with the name of the maker, and current and voltage for which the device is designed.

Link-Fuse Cut-Outs.

(Cut-outs of porcelain are not approved for link fuses.)

The following rules are intended to cover open link fuses mounted on slate or marble bases, including switchboards, tablet-boards, and single fuse-blocks. They do not apply to fuses mounted on porcelain bases, to the ordinary porcelain cut-out blocks, enclosed fuses, or any special or covered type of fuse. When tablet-boards or single fuse-blocks with such open link fuses on them are used in general wiring, they must be enclosed in cabinet boxes made to meet the requirements of No. 54. This is necessary, because a severe flash may occur when such fuses melt, so that they would be dangerous if exposed in the neighborhood of any combustible material.

f. **Base.**—Must be mounted on slate or marble bases. Bases with an area of over twenty-five square inches must have at least four supporting screws. Holes for supporting screws must be kept outside of the area included by the outside edges of the fuse-block terminals, and must be so located or countersunk that there will be at least one half of an inch space, measured over the surface, between the head of the screw or washer and the nearest live part.

g. **Mounting.**—Nuts or screw-heads on the under side of the base must be countersunk not less than one-eighth inch, and covered with a waterproof compound which will not melt below 150 degrees Fahrenheit.

52. Cut-Outs and Circuit-Breakers—Continued.

h. **Metal.**—All fuse-block terminals must have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load. Terminals, as far as practicable, should be made of compact form instead of being rolled out in thin strips ; and sharp edges or thin projecting pieces, as on wing thumb nuts and the like, should be avoided. Thin metal, sharp edges and projecting pieces are much more likely to cause an arc to start than a more solid mass of metal. It is a good plan to round all corners of the terminals and to chamfer the edges.

i. **Connections.**—Clamps for connecting the wires to the fuse-block terminals must be of solid, rugged construction, so as to insure a thoroughly good connection and to withstand considerable hard usage. For fuses rated at over thirty amperes, lugs firmly screwed or bolted to the terminals and into which the conducting wires are soldered must be used.

See note under No. 51 *h*.

j. **Test.**—Must operate successfully when blowing only one fuse at a time on short-circuits with fuses rated at 50 per cent above and with a voltage 25 per cent above the current and voltage for which the cut-out is designed.

k. **Marking.**—Must be plainly marked, where it will be visible when the cut-out block is installed, with the name of the maker and the current and the voltage for which the block is designed.

l. **Spacings.**—Spacings must be at least as great as those given in the following table, which applies only to plain, open link-fuses mounted on slate or marble bases. The spacings given are correct for fuse-blocks to be used on direct-current

52. Cut-Outs and Circuit-Breakers—Continued.

systems, and can therefore be safely followed in devices designed for alternating currents. If the copper fuse-tips overhang the edges of the fuse-block terminals, the spacings should be measured between the nearest edges of the tips.

125 VOLTS OR LESS:	Minimum Separation of Nearest Metal Parts of Opposite Polarity.	Minimum Break Distance.
10 amperes or less	¾ inch	¾ inch
11-100 amperes	1 "	¾ "
101-300 "	1 "	1 "
301-1000 "	1¼ "	1¼ "
126 TO 250 VOLTS:		
10 amperes or less	1½ inch	1½ inch
11-100 amperes	1¾ "	1¾ "
101-300 "	2 "	1½ "
301-1000 "	2½ "	2 "

A space must be maintained between fuse terminals of the *same polarity* of at least one-half inch for voltages up to 125 and of at least three-quarter inch for voltages from 126 to 250. This is the minimum distance allowable, and greater separation should be provided when practicable.

For 250 volt boards or blocks with the ordinary front-connected terminals, except where these have a mass of compact form, equivalent to the back-connected terminals usually found in switchboard work, a substantial barrier of insulating material, not less than one eighth of an inch in thickness, must be placed in the "break" gap,—this barrier to extend out from the base at least one eighth of an inch farther than any bare live part of the fuse-block terminal, including binding screws, nuts, and the like.

For three-wire systems cut-outs must have the break-distance required for circuits of the potential of the outside wires.

Enclosed-Fuse Cut-Outs,—Plug and Cartridge Type.

m. **Base.**—Must be made of non-combustible, non-absorptive insulating material. Blocks with an area of over twenty-five square inches must have at least four supporting screws. Holes for

52. Cut-Outs and Circuit-Breakers—Continued.

supporting screws must be so located or countersunk that there will be at least one half of an inch space, measured over the surface, between the screw-head or washer and the nearest live metal part, and in all cases when between parts of opposite polarity must be countersunk.

n. **Mounting.**—Nuts or screw-heads on the under side of the base must be countersunk at least one eighth of an inch and covered with a waterproof compound which will not melt below 150 degrees Fahrenheit.

o. **Terminals.**—Terminals must be of either the Edison plug, spring clip, or knife blade type, of *approved* design, to take the corresponding standard enclosed fuses. They must be secured to the base by two screws or the equivalent, so as to prevent them from turning, and must be so made as to secure a thoroughly good contact with the fuse. End stops must be provided to insure the proper location of the cartridge fuse in the cut-out.

p. **Connections.**—Clamps for connecting wires to the terminals must be of a design which will ensure a thoroughly good connection, and must be sufficiently strong and heavy to withstand considerable hard usage. For fuses rated to carry over thirty amperes, lugs firmly screwed or bolted to the terminals and into which the connecting wires shall be soldered must be used.

q. **Classification.**—Must be classified as regards both current and voltage as given in the following table, and must be so designed that the bases of

52. Cut-Outs and Circuit-Breakers—Continued.

one class cannot be used with fuses of another class rated for a higher current or voltage.

0–250 VOLTS.	251–600 VOLTS.
0– 30 amperes.	0– 30 amperes.
31– 60 "	31– 60 "
61–100 "	61–100 "
101–200 "	101–200 "
201–400 "	201–400 "
401–600 "	

r. **Design.**—Must be of such a design that it will not be easy to form accidental short-circuits across live metal parts of opposite polarity on the block or on the fuses in the block.

s. **Marking.**—Must be marked, where it will be plainly visible when the block is installed, with the name of the maker and the voltage and range of current for which it is designed.

53. Fuses.

(For installation rules, see Nos. 17 and 21.)

Link Fuses.

a. **Terminals.**—Must have contact surfaces or tips of harder metal, having perfect electrical connections with the fusible part of the strip.

The use of the hard metal tip is to afford a strong mechanical bearing for the screws, clamps, or other devices provided for holding the fuse.

b. **Rating.**—Must be stamped with about 80 per cent of the maximum current which they can carry indefinitely, thus allowing about 25 per cent overload before the fuse melts.

With naked open fuses, of ordinary shapes and with not over 500 amperes capacity, the *minimum* current which will melt them in about five minutes may be safely taken as the melting point, as the fuse practically reaches its maximum temperature in this time. With larger fuses a longer time is necessary. This data is given to facilitate testing.

53. Fuses—Continued.

c. **Marking.**—Fuse terminals must be stamped with the maker's name or initials, or with some known trade mark.

Enclosed Fuses,—Plug and Cartridge Type.

These requirements do not apply to fuses for rosettes, attachment plugs, car lighting, cut-outs and protective devices for signaling systems.

d. **Construction.**—The fuse plug or cartridge must be sufficiently dust-tight so that lint and dust cannot collect around the fusible wire and become ignited when the fuse is blown.

The fusible wire must be attached to the plug or cartridge terminals in such a way as to secure a thoroughly good connection and to make it difficult for it to be replaced when melted.

e. **Classification.**—Must be classified to correspond with the different classes of cut-out blocks, and must be so designed that it will be impossible to put any fuse of a given class into a cut-out block which is designed for a current or voltage lower than that of the class to which the fuse belongs.

53. Fuses—Continued.

f. **Terminals.**—The fuse terminals must be sufficiently heavy to ensure mechanical strength and rigidity. The styles of terminals must be as follows:—

0–250 Volts.

0–30	"	*A* Cartridge fuse (ferrule contact) to fit *a*, spring clip terminals. *b*, Edison plug casings. *B* Approved plugs for Edison cut-outs.
31–60	"	Cartridge fuse (ferrule contact) to fit *a*, spring clip terminals. *b*, Edison plug casings.
61–100	"	Cartridge fuse (knife blade contact).
101–200	"	
201–400	"	
401–600	"	

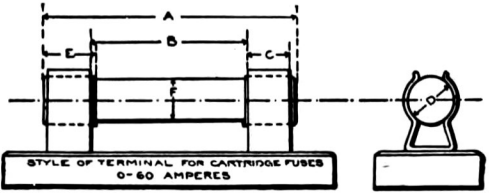
251–600 Volts.

0–30	amps.	Cartridge fuse (ferrule contact).
31–60	"	
61–100	"	Cartridge fuse (knife blade contact).
101–200	"	
201–400	"	

g. **Dimensions.**—Cartridge enclosed fuses and corresponding cut-out blocks must conform to the dimensions given in the table attached.

53. Fuses.—Continued.

TABLE OF DIMENSIONS OF THE STANDARD CARTRIDGE

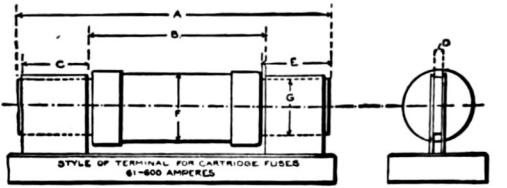


Form 1. CARTRIDGE FUSE—Ferrule Contact.

Voltage.	Rated Capacity. Amperes.	A Length over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches.
0-250	0-30	Form 1 2	1	1/2
	31-60	Form 1 3	1 3/4	5/8
	61-100	Form 2 5 7/8	4	7/8
	101-200	Form 2 7 1/8	4 1/2	1 1/4
	201-400	Form 2 8 5/8	5	1 3/4
	401-600	Form 2 10 3/8	6	2 1/8
251-600	0-30	Form 1 5	4	1/2
	31-60	Form 1 5 1/2	4 1/4	5/8
	61-100	Form 2 7 7/8	6	7/8
	101-200	Form 2 9 5/8	7	1 1/4
	201-400	Form 2 11 5/8	8	1 3/4

53. Fuses.—Continued.

NATIONAL ELECTRICAL CODE ENCLOSED FUSE.



Form 2. CARTRIDGE FUSE—Knife Blade Contact.

D	E	F	G		Rated Capacity.
Diameter of Ferrules or Thickness of Terminal Blades. Inches.	Min. Length of Ferrules or of Terminal Blades outside of Tube. Inches.	Dia. of Tube. Inches	Width of Terminal Blades. Inches.		Amperes.
9/16	1/2	1/2		Form 1	0-30
13/16	5/8	3/4			31-60
1/8	1	1	3/4	Form 2	61-100
3/16	1 3/8	1 1/2	1 1/8		101-200
1/4	1 7/8	2	1 5/8		201-400
1/4	2 1/4	2 1/2	2		401-600
13/16	1/2	3/4		Form 1	0-30
1 1/16	5/8	1			31-60
1/8	1	1 1/4	3/4	Form 2	61-100
3/16	1 3/8	1 3/4	1 1/8		101-200
1/4	1 7/8	2 1/2	1 5/8		201-400

53. Fuses—Continued.

h. **Rating.**—Fuses must be so constructed that with the surrounding atmosphere at a temperature of 75 degrees Fahrenheit they will carry indefinitely a current 10 per cent greater than that at which they are rated, and at a current 25 per cent greater than the rating, they will open the circuit without reaching a temperature which will injure the fuse tube or terminals of the fuse block. With a current 50 per cent greater than the rating and at room temperature of 75 degrees Fahrenheit, the fuses, starting cold, must blow within the time specified.

0- 30 amperes,	30 seconds.
31- 60 "	1 minute.
61-100 "	2 minutes.
101-200 "	4 "
201-400 "	8 "
401-600 "	10 "

i. **Marking.**—Must be marked, where it will be plainly visible, with the name or trade mark of the maker, the voltage and current for which the fuse is designed, and the words "National Electrical Code Standard." Each fuse must have a label, the color of which must be green for 250-volt fuses and red for 600-volt fuses.

It will be satisfactory to abbreviate the above designation to "N. E. Code St'd" where space is necessarily limited.

j. **Temperature Rise.**—The temperature of the exterior of the fuse enclosure must not rise more than 125 degrees Fahrenheit above that of the surrounding air when the fuse is carrying the current for which it is rated.

k. **Test.** Must not hold an arc or throw out melted metal or sufficient flame to ignite easily inflammable material on or near the cut-out, when

53. Fuses—Continued.

only one fuse is blown at a time on a short-circuit, on a system having a capacity of 300 K. W. or over, at the voltage for which the fuse is rated.

The above requirement that the testing circuit must have a capacity of at least 300 K. W. is to guard against making the test on a system of so small capacity that the conditions would be sufficiently favorable to allow really poor fuses to stand the test acceptably. On the other hand, it must be remembered that if the test is made on a system of very large capacity, and especially if there is but little resistance between the generators and fuse, the conditions may be more severe than are liable to be met with in practice outside of the large power stations, the result being that fuses entirely safe for general use may be rejected if such test is insisted upon. A more definite rule regarding the conditions of this test is desirable, and the matter is under consideration. In any case the test should be arranged to best represent the severer conditions of actual practice, not, however, including central station equipments where specially designed and stronger fuses are undoubtedly necessary.

53 A. Tablet and Panel Boards.

The following minimum distance between bare live metal parts (bus-bars, etc.) must be maintained:—

Between parts of opposite polarity, except at switches and link fuses.		Between parts of same polarity.
When mounted on the same surface.	When held free in the air.	At link fuses.
0–125 volts ¾ inch	½ inch	½ inch
126–250 volts 1¼ "	¾ "	¾ "

At switches or enclosed fuses, parts of the same polarity may be placed as close together as convenience in handling will allow.

53 A. Tablet and Panel Boards—Continued.

It should be noted that the above distances are the *minimum* allowable, and it is urged that greater distances be adopted wherever the conditions will permit.

The spacings given in the first column apply to the branch conductors where enclosed fuses are used. Where link fuses or knife switches are used, the spacings must be at least as great as those required by Nos. 51 and 52.

The spacings given in the second column apply to the distance between the raised main bars, and between these bars and the branch bars over which they pass.

The spacings given in the third column are intended to prevent the melting of a link fuse by the blowing of an adjacent fuse of the same polarity.

54. Cut-Out Cabinets.

a. **Material.**—Cabinets must be substantially constructed of non-combustible, non-absorptive material, or of wood. When wood is used the inside of the cabinet must be completely lined with a non-combustible insulating material. Slate or marble at least one-quarter inch in thickness is strongly recommended for such lining, but, except with metal conduit systems, asbestos board at least one-eighth inch in thickness may be used in dry places if firmly secured by shellac and tacks.

With metal conduit systems the lining of either the box or the gutter must be of one-sixteenth inch galvanized, painted or enameled iron, or preferably one-quarter inch slate or marble.

The object of the lining of such cut-out cabinets or gutters is to render the same approximately fireproof in case of short circuit after the wires leave the protecting metal conduits.

Two thicknesses of 1-32 inch iron may be used instead of one of 1-16 inch.

54. Cut-Out Cabinets—Continued.

With wood cabinets the wood should be thoroughly filled and painted before the lining is put in place.

b. **Door.**—The door must close against a rabbet, so as to be perfectly dust-tight. Strong hinges and a strong hook or catch are required. Glass doors must be glazed with heavy glass, not less than 1-8 inch in thickness, and panes should not exceed 300 square inches in area. A space or at least two inches must be allowed between the fuses and the door. This is necessary to prevent cracking or breaking by the severe blow and intense heat which may be produced under some conditions.

A cabinet is of little use unless the door is kept tightly closed, and especial attention is therefore called to the importance of having a strong and reliable catch or other fastening. A spring catch is advised if a good one can be obtained, but most of those sold for use on cupboards, etc., are so small that they fail to catch when the door shrinks a little, or are so weak that they soon give out.

c. **Bushings.**— Bushings through which wires enter must fit tightly the holes in the box, and must be of approved construction. The wires should completely fill the holes in the bushings, using tape to build up the wire, if necessary, so as to keep out the dust.

54 A. Rosettes.

Ceiling rosettes, both fused and fuseless, must be constructed in accordance with the following specifications:—

a. **Base.**— Current-carrying parts must be mounted on non-combustible, non-absorptive in-

54 A. Rosettes—Continued.

sulating bases. There should be no openings through the rosette base except those for the supporting screws and in the concealed type for the conductors also, and these openings should not be made any larger than necessary.

There must be at least 1-4 inch space, measured over the surface, between supporting screws and current-carrying parts. The supporting screws must be so located or countersunk that the flexible cord cannot come in contact with them.

Bases for the knob and cleat type must have at least two holes for supporting screws; must be high enough to keep the wires and terminals at least 1-2 inch from the surface to which the rosette is attached, and must have a porcelain lug under each terminal to prevent the rosette from being placed over projections which would reduce the separation to less than 1-2 inch.

Bases for the moulding and conduit box types must be high enough to keep the wires and terminals at least 3-8 inch from the surface wired over.

b. **Mounting.**—Contact pieces and terminals must be secured in position by at least two screws, or made with a square shoulder, or otherwise arranged to prevent turning.

The nuts or screw heads on the under side of the base must be countersunk not less than 1-8 inch and covered with a waterproof compound which will not melt below 150 deg. Fahr.

c. **Terminals.**—Line terminal plates must be at least .07 inch in thickness, and terminal screws must not be smaller than No. 6 standard screw with about 32 threads per inch.

Terminal plates for the flexible cord and for fuses must be at least .06 inch in thickness, and the

54 A. Rosettes—Continued.

terminal screws must not be smaller than No. 5 standard screw with about 40 threads per inch.

d. **Cord Inlet.**—The diameter of the cord inlet hole should measure 13-32 inch in order that standard portable cord may be used.

e. **Knot Space.**—Ample space must be provided for a substantial knot tied in the cord as a whole. All parts of the rosette upon which the knot is likely to bear must be smooth and well rounded.

f. **Cover.**—When the rosette is made in two parts, the cover must be secured to the base so that it will not work loose.

In fused rosettes, the cover must fit closely over the base so as to prevent the accumulation of dust or dirt on the inside, and also to prevent any flash or melted metal from being thrown out when the fuses melt.

g. **Markings.**—Must be plainly marked where it may readily be seen after the rosette has been installed, with the name or trade mark of the manufacturer, and the rating in amperes and volts. Fuseless rosettes may be rated 3 amperes, 250 volts; fused rosettes, with link fuses, not over 2 amperes, 125 volts.

h. **Test.**—Fused rosettes must have a fuse in each pole and must operate successfully when short-circuited on the voltage for which they are designed, the test being made with the two fuses in circuit.

When link fuses are used the test shall be made with fuse wire which melts at about 7 amperes in one inch lengths. The larger fuse is specified for the test in order to more nearly approximate the severe con-

54 A. Rosettes—Continued.

ditions obtained when only one 2-ampere fuse (the rating of the rosette) is blown at a time.

Fused rosettes equipped with enclosed fuses are much preferable to the link fuse rosettes.

55. Sockets.

(For installation rules, see No. 27.)

Sockets of all kinds, including wall receptacles, must be constructed in accordance with the following specifications.

a. **Standard Sizes.**—The standard lamp socket must be suitable for use on any voltage not exceeding 250 and with any size lamp up to fifty candle-power. For lamps larger than fifty candle-power a standard keyless socket may be used, or if a key is required, a special socket designed for the current to be used must be made. Any special sockets must follow the general spirit of these specifications.

b. **Marking.**—The standard socket must be plainly marked 250 v., 50 c. p., and with the manufacturer's name or registered trade mark. Special sockets must be marked with the current and voltage for which they are designed.

c. **Shell.**—Metal used for shells must be moderately hard, but not hard enough to be brittle or so soft as to be easily dented or knocked out of shape. Brass shells must be at least thirteen one-thousandths of an inch in thickness, and shells of any other material must be thick enough to give the same stiffness and strength as the required thickness of brass.

d. **Lining.**—The inside of the shells must be lined with insulating material, which must absolutely prevent the shell from becoming a part of the circuit, even though the wires inside the socket should start from their position under the binding screws.

55. Sockets—Continued.

The material used for lining must be at least one thirty-second of an inch in thickness, and must be tough and tenacious. It must not be injuriously affected by the heat from the largest lamp permitted in the socket, and must leave water in which it is boiled practically neutral. It must be so firmly secured to the shell that it will not fall out with ordinary handling of the socket. It is preferable to have the lining in one piece.

The cap must also be lined, and this lining must comply with the requirements for shell linings.

The shell lining should extend beyond the shell far enough so that no part of the lamp base is exposed when a lamp is in the socket.

e. **Cap.**—Caps, when of sheet brass, must be at least thirteen one-thousandths of an inch in thickness, and when cast or made of other metals must be of equivalent strength. The inlet piece, except for special sockets, must be tapped with a standard one-eighth-inch pipe thread. It must contain sufficient metal for a full, strong thread, and when not in one piece with the cap, must be joined to it in such a way as to give the strength of a single piece.

There must be sufficient room in the cap to enable the ordinary wireman to easily and quickly make a knot in the cord and to push it into place in the cap without crowding. All parts of the cap upon which the knot is likely to bear must be smooth and well insulated.

The cap lining called for in the note to Section *d* will provide a sufficiently smooth and well-insulated surface for the knot to bear upon.

Sockets with an outlet threaded for three-eighths inch pipe will, of course, be approved where circumstances demand their use. This size outlet is necessary with most stiff pendants and for the proper use of reinforced flexible cord, as explained in the note to No. 28 *d*.

f. **Frame and Screws.**—The frame which holds the moving parts must be sufficiently heavy to give ample strength and stiffness.

55. Sockets—Continued.

Brass pieces containing screw threads must be at least six one-hundredths of an inch in thickness.

Binding post screws must not be smaller than No. 5 standard screw with about 40 threads per inch.

g. **Spacing.**—Points of opposite polarity must everywhere be kept not less than three sixty-fourths of an inch apart, unless separated by a reliable insulation.

h. **Connections.**—The connecting points for the flexible cord must be made to very securely grip a No. 16 or 18 B. & S. gage conductor. A turned-up lug, arranged so that the cord may be gripped between the screw and the lug in such a way that it cannot possibly come out, is strongly advised.

i. **Lamp Holder.**—The socket must firmly hold the lamp in place so that it cannot be easily jarred out, and must provide a contact good enough to prevent undue heating with the maximum current allowed. The holding pieces, springs, and the like, if a part of the circuit, must not be sufficiently exposed to allow them to be brought in contact with anything outside of the lamp and socket.

j. **Base.**—With the exception of the lining, all parts of insulating material inside the shell must be made of porcelain.

k. **Key.**—The socket key-handle must be of such a material that it will not soften from the heat of a fifty candle-power lamp hanging downwards from the socket in air at 70 degrees Fahrenheit, and must be securely, but not necessarily rigidly, attached to the metal spindle which it is designed to turn.

55. Sockets—Continued.

l. **Sealing.**—All screws in porcelain pieces, which can be firmly sealed in place, must be so sealed by a waterproof compound which will not melt below 200 degrees Fahrenheit.

m. **Putting Together.**—The socket as a whole must be so put together that it will not rattle to pieces. Bayonet joints or an equivalent are recommended.

n. **Test.**—The socket, when slowly turned "on and off" at the rate of about two or three times per minute, while carrying a load of one ampere at 250 volts, must "make and break" the circuit 6,000 times before failing.

o. **Keyless Sockets.**—Keyless sockets of all kinds must comply with the requirements for key sockets as far as they apply.

p. **Sockets of Insulating Material.**—Sockets made of porcelain or other insulating material must conform to the above requirements as far as they apply, and all parts must be strong enough to withstand a moderate amount of hard usage without breaking.

Porcelain shell sockets being subject to breakage, and constituting a hazard when broken, will not be accepted for use in places where they would be exposed to hard usage.

q. **Inlet Bushing.**—When the socket is not attached to a fixture, the threaded inlet must be provided with a strong insulating bushing having a *smooth* hole at least nine thirty-seconds of an inch in diameter. The edges of the bushing must be rounded and all inside fins removed, so that in no place will the cord be subjected to the cutting or wearing action of a sharp edge.

Bushings for sockets having an outlet threaded for three-eighths-inch pipe should have a hole thirteen thirty-seconds of an inch in diameter, so that they will accommodate *approved* reinforced flexible cord.

56. Hanger-Boards for Series Arc Lamps.

a. Hanger-boards must be so constructed that all wires and current-carrying devices thereon will be exposed to view and thoroughly insulated by being mounted on a non-combustible, non-absorptive insulating substance. All switches attached to the same must be so constructed that they shall be automatic in their action, cutting off both poles to the lamp, not stopping between points when started and preventing an arc between points under all circumstances.

57. Arc Lamps.

(*For installation rules, see Nos. 19 and 29.*)

a. Must be provided with reliable stops to prevent carbons from falling out in case the clamps become loose.

b. All exposed parts must be carefully insulated from the circuit.

c. Must, for constant-current systems, be provided with an *approved* hand switch, and an automatic switch that will shunt the current around the carbons, should they fail to feed properly.

The hand switch to be approved, if placed anywhere except on the lamp itself, must comply with requirements for switches on hanger-boards as laid down in No. 56.

58. Spark Arresters.

(*For installation rules, see Nos. 19 c and 29 c.*)

a. Spark arresters must so close the upper orifice of the globe that it will be impossible for any sparks, thrown off by the carbons, to escape.

59. Insulating Joints.

(*See No. 26 a.*)

a. Must be entirely made of material that will resist the action of illuminating gases, and will not give way or soften under the heat of an ordinary gas flame or leak under a moderate pressure. Must be so arranged that a deposit of moisture will not destroy the insulating effect; must show a dielectric strength between gas-pipe attachments sufficient to resist throughout five minutes the application of an electro-motive force of 4000 volts; and must be sufficiently strong to resist the strain to which they are liable to be subjected during installation.

b. Insulating joints having soft rubber in their construction will not be approved.

60. Rheostats.

(*For installation rules, see Nos. 4 a and 8 c.*)

a. **Materials.**—Must be made entirely of non-combustible materials except such minor parts as handles, magnet insulation, etc.

All segments, lever arms, etc., must be mounted on non-combustible, non-absorptive, insulating material.

Resistance boxes are used for the express purpose of opposing the passage of current, and are therefore very liable to get exceedingly hot. Hence they should have no combustible material in their construction.

b. **Construction.**—Must have legs which will keep the current-carrying parts at least one inch from the surface on which the rheostat is mounted.

The construction throughout must be heavy, rugged, and thoroughly workmanlike.

c. **Connections.**—Clamps for connecting wires to the terminals must be of a design which will ensure

60. Rheostats—Continued.

a thoroughly good connection, and must be sufficiently strong and heavy to withstand considerable hard usage. For currents above fifty amperes, lugs firmly screwed or bolted to the terminals, and into which the connecting wires shall be soldered, must be used.

Clamps or lugs will not be required when leads designed for soldered connections are provided.

d. **Marking.**—Must be plainly marked, where it may be readily seen after the device is installed, with the rating and the name of the maker; and the terminals of motor-starting rheostats must be marked to indicate to what part of the circuit each is to be connected, as "line," "armature," and "field."

e. **Contacts.**—The design of the fixed and movable contacts and the resistance in each section must be such as to secure the least tendency towards arcing and roughening of the contacts, even with careless handling or the presence of dirt.

In motor-starting rheostats, the contact at which the circuit is broken by the lever arm when moving from the running to the starting position, must be so designed that there will be no detrimental arcing. The final contact, if any, on which the arm is brought to rest in the starting position must have no electrical connection.

Experience has shown that sharp edges and segments of thin material help to maintain an arc, and it is recommended that these be avoided. Segments of heavy construction have a considerable cooling effect on the arc, and rounded corners tend to spread it out and thus dissipate it.

f. **No-voltage release.**—Motor-starting rheostats must be so designed that the contact arm cannot be left on intermediate segments, and must be provided with an automatic device which will

60. Rheostats—Continued.

interrupt the supply circuit before the speed of the motor falls to less than one third of its normal value.

g. **Overload-release.**—Overload-release devices which are inoperative during the process of starting a motor will not be approved, unless other circuit-breakers or fuses are installed in connection with them.

If, for instance, the overload-release device simply releases the starting arm and allows it to fly back and break the circuit, it is inoperative while the arm is being moved from the starting to the running position.

h. **Test.**—Must, after 100 operations under the most severe normal conditions for which the device is designed, show no serious burning of the contacts or other faults, and the release mechanism of motor-starting rheostats must not be impaired by such a test.

Field rheostats, or main-line regulators intended for continuous use, must not be burned out or depreciated by carrying the full normal current on any step for an indefinite period. Regulators intended for intermittent use (such as on electric cranes, elevators, etc.) must be able to carry their rated current on any step for as long a time as the character of the apparatus which they control will permit them to be used continuously.

61. Reactive Coils and Condensers.

a. Reactive coils must be made of non-combustible material, mounted on non-combustible bases and treated, in general, as sources of heat.

b. Condensers must be treated like other apparatus operating with equivalent voltage and currents. They must have non-combustible cases and supports, and must be isolated from all combustible materials and, in general, treated as sources of heat.

62. Transformers.

(*For installation rules, see Nos. 11, 13, 13 A and 36.*)

a. Must not be placed in any but metallic or other non-combustible cases.

On account of the possible dangers from burn-outs in the coils. (See note under No. 11 *a.*)

It is advised that every transformer be so designed and connected that the middle point of the secondary coil can be reached if, at any future time, it should be desired to ground it.

b. Must be constructed to comply with the following tests:—

1. Shall be run for eight consecutive hours at full load in watts under conditions of service, and at the end of that time the rise in temperature, as measured by the increase of resistance of the primary coil, shall not exceed 135 degrees Fahrenheit.
2. The insulation of transformers when heated shall withstand continuously for five minutes a difference of potential of 10,000 volts (alternating) between primary and secondary coils and between the primary coils and core, and a no-load "run" at double voltage for thirty minutes.

63. Lightning Arresters.

(*For installation rules, see No. 5.*)

a. Lightning arresters must be of *approved* construction. (See list of Electrical Fittings.)

CLASS E.

MISCELLANEOUS.

64. Signaling Systems.

Governing wiring for telephone, telegraph, district messenger and call-bell circuits, fire and burglar alarms, and all similar systems which are hazardous only because of their liability to become crossed with electric light, heat, or power circuits.

When the entire circuit from Central Station to building is run in underground conduits, Sections *a* to *m* inclusive do not apply.

a. Outside wires should be run in underground ducts or strung on poles, and, as far as practicable, kept off of buildings, and must not be placed on the same cross-arm with electric light or power wires. They should not occupy the same duct, manhole or handhole of conduit systems with electric light or power wires.

Single manholes, or handholes, may be separated into sections by means of partitions of brick or tile so as to be considered as conforming with the above rule.

The liability of accidental crossing of overhead signaling circuits with electric light and power circuits may be guarded against to a considerable extent by endeavoring to keep the two classes of circuits on different sides of the same street.

b. When outside wires are run on same pole with electric light or power wires, the distance between the two inside pins of each cross-arm must not be less than twenty-six inches.

Signaling wires being smaller and more liable to break and fall, should generally be placed on the lower cross-arms.

64. Signaling Systems—Continued.

c. Where wires are attached to the outside walls of buildings they must have an approved rubber insulating covering (see No. 41), and on frame buildings or frame portions of other buildings shall be supported on glass petticoat insulators, or porcelain knobs.

d. The wires from last outside support to the cut-outs or protectors must be of copper, and must have an approved rubber insulation (see No. 41); must be provided with drip loops immediately outside the building and at entrance; must be kept not less than two and one-half inches apart.

e. Wires must enter building through approved non-combustible, non-absorptive, insulating bushings sloping upward from the outside.

Installations where the Current Carrying Parts of the Apparatus Installed are Capable of Carrying Indefinitely a Current of Ten Amperes.

f. An all-metallic circuit shall be provided, except in telegraph systems.

g. At the entrance of wires to buildings, approved single pole cut-outs, designed for 251–600 volts potential and containing fuses rated at not over ten amperes capacity, shall be provided for each wire. These cut-outs must not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases, or dust or to flyings of combustible material.

h. The wires inside building shall be of copper not less than No. 16 B. & S. gage, and must have insulation and be supported, the same as would be required for an installation of electric light or power wiring, 0–550 volts potential.

i. The instruments shall be mounted on bases constructed of non-combustible, non-absorptive,

64. Signaling Systems—Continued.

insulation material. Holes for the supporting screws must be so located, or countersunk, that there will be at least one half of an inch space, measured over the surface, between the head of the screw and the nearest live metal part.

Installations where the Current Carrying Parts of the Apparatus Installed are Not Capable of Carrying Indefinitely a Current of Ten Amperes.

j. Must be provided with an *approved* protective device located as near as possible to the entrance of wires to building. The protector must not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases or dust or flyings of combustile material.

k. Wires from entrance to building to protector must be supported on porcelain insulators, so that they will come in contact with nothing except their designed supports.

l. The ground wire of the protective device shall be run in accordance with the following requirements:—

1. Shall be of copper, and not smaller than No. 18 B. & S. gage.
2. Must have an approved rubber insulating covering (see No. 41).
3. Must run in as straight a line as possible to a good permanent ground. This may be obtained by connecting to a water or gas pipe connected to the street mains and in service, or to a ground rod or pipe driven in permanently damp earth. When connections are made to pipes, preference shall be given to water pipes. If attachment is made to gas pipe, the connection in all cases must be made between the

64. Signaling Systems—Continued.

meter and the street mains. In every case the connection shall be made as near as possible to the earth.

When the ground wire is attached to water or gas pipes, these pipes shall be thoroughly cleaned and tinned with rosin flux solder, if such a method is practicable; the ground wire shall then be wrapped tightly around the pipe and thoroughly soldered to it.

When the above method is impracticable, then if there are fittings where a brass plug can be inserted, the ground wire shall be thoroughly soldered to it; if there are no such fittings, then the pipe shall be thoroughly cleaned and an approved ground clamp fastened to an exposed portion of the pipe and the ground wire well soldered to the ground clamp.

When the ground wire is attached to a ground rod driven into the earth, the ground wire shall be soldered to the rod in a similar manner.

Steam or hot-water pipes must not be used for a protector ground.

m. The protector to be approved must comply with the following requirements: —

For Instrument Circuits of Telegraph Systems.

1. An approved single pole cut-out, in each wire, designed for 2,000 volts potential, and containing fuses rated at not over one ampere capacity. When main line cut-outs are installed as called for in section *g*, the instrument cut-outs may be placed between the switch board and the instrument as near the switch board as possible.

64. Signaling Systems—Continued.

For All Other Systems.

1. Must be mounted on non-combustible, non-absorptive insulating bases, so designed that when the protector is in place, all parts which may be alive will be thoroughly insulated from the wall to which the protector is attached.

2. Must have the following parts: —

A lightning arrester which will operate with a difference of potential between wires of not over 500 volts, and so arranged that the chance of accidental grounding is reduced to a minimum.

A fuse designed to open the circuit in case the wires become crossed with light or power circuits. The fuse must be able to open the circuit without arcing or serious flashing when crossed with any ordinary commercial light or power circuit.

A heat coil, if the sensitiveness of the instrument demands it, which will operate before a sneak current can damage the instrument the protector is guarding.

Heat coils are necessary in all circuits normally closed through magnet windings, which cannot indefinitely carry a current of at least five amperes.

The heat coil is designed to warm up and melt out with a current large enough to endanger the instruments if continued for a long time, but so small that it would not blow the fuses ordinarily found necessary for such instruments. These smaller currents are often called "sneak" currents.

3. The fuses must be so placed as to protect the arrester and heat coils, and the protector terminals must be plainly marked "line," "instrument," "ground."

An easily read abbreviation of the above words will be allowed.

64. Signaling Systems—Continued.

The Following Rules Apply to All Systems whether the Wires from the Central Office to the Building are Overhead or Underground.

n. Wires beyond the protector, or wires inside buildings where no protector is used, must be neatly arranged and securely fastened in place in some convenient, workmanlike manner. They must not come nearer than six inches to any electric light or power wire in the building unless encased in *approved* tubing so secured as to prevent its slipping out of place.

The wires would ordinarily be insulated, but the kind of insulation is not specified, as the protector is relied upon to stop all dangerous currents. Porcelain tubing or *approved* flexible tubing may be used for encasing wires where required as above.

o. Wires where bunched together within any building must have fire-resisting covering, or else be encased in a non-combustible tube or shaft.

They must not be in the same tube with electric light or power wires, and if in the same shaft must be kept at least two inches from such wires. Ducts or shafts for wires must be of fireproof construction and thoroughly "stopped" at each floor or wall.

Ordinary rubber insulation is inflammable, and when a number of wires are contained in a shaft or duct extending through a building, a ready means of carrying fire from floor to floor exists unless the shaft or duct is "stopped" at floors and walls.

65. Electric Gas Lighting.

a. Electric gas lighting must not be used on the same fixture with the electric light.

The above rule does not apply to ***frictional*** systems of gas lighting.

65 A. Moving Picture Machines.

a. Top reel must be encased in an iron box with hole at the bottom only large enough for film to pass through, and cover so arranged that this hole can be instantly closed. No solder to be used in the construction of this box.

b. A box must be used for receiving the film after being shown, made of galvanized iron with a hole in the top only large enough for the film to pass through freely, with a cover so arranged that this hole can be instantly closed. An opening may be placed at the side of the box to take the film out, with a door hung at the top, so arranged that it cannot be entirely opened, and provided with a spring catch to lock it closed. No solder to be used in the construction of this box.

c. The handle or crank used in operating the machine must be secured to the spindle or shaft so that there will be no liability of its coming off and allowing the film to stop in front of the lamp.

d. A shutter must be placed in front of the condenser, arranged so as to be normally closed, and held open by pressure of the foot.

e. A metal pan must be placed under the arc lamp to catch all sparks.

f. Extra films must be kept in metal box with tight-fitting covers.

66. Insulation Resistance.

The wiring in any building must test free from grounds; *i. e.*, the complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) not less than that given in the following table:—

66. Insulation Resistance—Continued.

Up to	5	amperes	4,000,000	ohms.
"	10	"	2,000,000	"
"	25	"	800,000	"
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	50,000	"
"	800	"	25,000	"
"	1,600	"	12,500	"

The test must be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only one half of the resistances specified in the table will be required.

67. Soldering Fluid.

a. The following formula for soldering fluid is suggested:—

Saturated solution of zinc chloride	5 parts
Alcohol	4 parts
Glycerine	1 part

MARINE WORK.

68. Generators.

a. Must be located in a dry place.

b. Must have their frames insulated from their bed-plates.

c. Must each be provided with a waterproof cover.

d. Must each be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

69. Wires.

a. Must be supported in *approved* moulding or conduit, except at switchboards and for portables.

Special permission may be given for deviation from this rule in dynamo-rooms.

b. Must have no single wire larger than No. 12 B. & S. gage. Wires to be stranded when greater carrying capacity is required. No single solid wire smaller than No. 14 B. & S. gage, except in fixture wiring, to be used.

Stranded wires must be soldered before being fastened under clamps or binding screws, and when they have a conductivity greater than that of No. 8 B. & S. gage copper wire they must be soldered into lugs.

c. Splices or taps in conductors must be avoided as far as possible. Where it is necessary to make them they must be so spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered, to insure

69. Wires—Continued.

preservation, covered with an insulating compound equal to the insulation of the wire, and further protected by a waterproof tape. The joint must then be coated or painted with a waterproof compound.

For Moulding Work.

d. Must have an *approved* insulating covering.

The insulation for conductors, to be approved, must be at least 3-32 of an inch in thickness and be covered with a substantial waterproof braid.

The physical characteristics shall not be affected by any change in temperature up to 200 degrees Fahrenheit. After two weeks' submersion in salt water at 70 degrees Fahrenheit, it must show an insulation resistance of 100 megohms per mile after three minutes' electrification with 550 volts.

e. Must have, when passing through water-tight bulkheads and through all decks, a metallic stuffing tube lined with hard rubber. In case of deck tubes, they shall be boxed near deck to prevent mechanical injury.

f. Must be bushed with hard rubber tubing, one eighth of an inch in thickness, when passing through beams and non-water-tight bulkheads.

For Conduit Work.

g. Must have an *approved* insulating covering.

The insulation for conductors, for use in lined conduits, to be approved, must be at least 3-32 of an inch in thickness and be covered with a substantial waterproof and flameproof braid. The physical characteristics shall not be affected by any change in temperature up to 200 degrees Fahrenheit.

After two weeks' submersion in salt water at 70 degrees Fahrenheit, it must show an insulation resistance of 100 megohms per mile after three minutes' electrification with 550 volts.

For unlined metal conduits, conductors must conform to the specifications given for lined conduits, and in addition have a second outer fibrous

69. Wires—Continued.

covering at least one thirty-second of an inch in thickness, and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

h. Must not be drawn in until the mechanical work on the conduit is completed and same is in place.

i. Where run through coal bunkers, boiler rooms, and where they are exposed to severe mechanical injury, must be encased in *approved* conduit.

70. Portable Conductors.

a. Must be made of two stranded conductors, each having a carrying capacity equivalent to not less than No. 14 B. & S. gage wire, and each covered with an *approved* insulation and covering.

Where not exposed to moisture or severe mechanical injury, each stranded conductor must have a solid insulation at least one thirty-second of an inch in thickness, and must show an insulation resistance between conductors, and between either conductor and the ground, of at least fifty megohms per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and be protected by a slow-burning, tough-braided outer covering.

Where exposed to moisture and mechanical injury—as for use on decks, holds and fire-rooms—each stranded conductor shall have a solid insulation, to be approved, of at least one thirty-second of an inch in thickness and protected by a tough braid. The two conductors shall then be stranded together, using a jute filling. The whole shall then be covered with a layer of flax, either woven or braided, at least one thirty-second of an inch in thickness, and treated with a non-inflammable, waterproof compound. After one week's submersion in water at 70 degrees Fahrenheit, it must show an insulation between the two conductors, or between either conductor and the ground, of fifty megohms per mile.

71. Bell or Other Wires.

a. Shall never be run in same duct with lighting or power wires.

72. Table of Capacity of Wires.

B. & S. G.	Area Actual C. M.	No. of Strands.	Size of Strands B. & S. G.	Amperes.
19	1,288	..	..	..
18	1,624	..	..	3
17	2,048	..	..	..
16	2,583	..	..	6
15	3,257	..	..	..
14	4,107	..	..	12
12	6,530	..	..	17
..	9,016	7	19	21
..	11,368	7	18	25
..	14,336	7	17	30
..	18,081	7	16	35
..	22,799	7	15	40
..	30,856	19	18	50
..	38,912	19	17	60
..	49,077	19	16	70
..	60,088	37	18	85
..	75,776	37	17	100
..	99,064	61	18	120
..	124,928	61	17	145
..	157,563	61	16	170
..	198,677	61	15	200
..	250,527	61	14	235
..	296,387	91	15	270
..	373,737	91	14	320
..	413,639	127	15	340

When greater conducting area than that of 12 B. & S. gage is required, the conductor shall be stranded in a series of 7, 19, 37, 61, 91 or 127 wires, as may be required; the strand consisting of one central wire, the remainder laid around it concentrically, each layer to be twisted in the opposite direction from the preceding.

73. Switchboard.

a. Must be made of non-combustible, non-absorptive insulating material, such as marble or slate.

b. Must be kept free from moisture, and must be located so as to be accessible from all sides.

c. Must have a main switch, main cut-out and ammeter for each generator.

73. Switchboard—Continued.

Must also have a voltmeter and ground detector.

d. Must have a cut-out and switch for each side of each circuit leading from board.

74. Resistance Boxes.

(*For construction rules, see No. 60.*)

a. Must be located on switchboard or away from combustible material. When not placed on switchboard they must be mounted on non-inflammable, non-absorptive insulating material.

75. Switches.

(*For construction rules, see No. 51.*)

a. Must not be single pole when the circuits which they control supply devices which require over 660 watts of energy.

b. When exposed to dampness, they must be enclosed in a water-tight case.

c. Must be of the knife pattern when located on switchboard.

d. Must be provided so that each freight compartment may be separately controlled.

76. Cut-Outs.

(*For construction rules, see No. 52.*)

a. Must be placed at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller).

b. In places such as upper decks, holds, cargo spaces and fire-rooms, a water-tight and fireproof cut-out may be used, connecting directly to mains when such cut-out supplies circuits requiring not more than 660 watts energy.

76. Cut-Outs—Continued.

c. When placed anywhere except on switchboards and certain places, as cargo spaces, holds, fire-rooms, etc., where it is impossible to run from center of distribution, they shall be in a cabinet lined with fire-resisting material.

d. Except for motors, searchlights and diving lamps shall be so placed that no group of lamps, requiring a current of more than 660 watts, shall ultimately be dependent upon one cut-out.

77. Fixtures.

a. Shall be mounted on blocks made from well-seasoned lumber treated with two coats of white lead or shellac.

b. Where exposed to dampness, the lamp must be surrounded by a vapor-proof globe.

c. Where exposed to mechanical injury, the lamp must be surrounded by a globe protected by a stout wire guard.

d. Shall be wired with same grade of insulation as portable conductors which are not exposed to moisture or mechanical injury.

e. Ceiling fixtures over two feet in length must be provided with stay chains.

78. Sockets.

(*For construction rules, see No. 55.*)

79. Wooden Mouldings.

(*For construction rules, see No. 50.*)

a. Where moulding is run over rivets, beams, etc., a backing strip must first be put up and the moulding secured to this.

b. Capping must be secured by brass screws.

80. Interior Conduits.

(*For installation rules, see No. 25.*)

(*For construction rules, see No. 49.*)

81. Signal Lights.

a. Must be provided with *approved* telltale board, located preferably in pilot-house, which will immediately indicate a burned-out lamp.

82. Motors.

a. Must be wired under the same precautions as with a current of same volume and potential for lighting. The motor and resistance box must be protected by a double-pole cut-out and controlled by a double-pole switch, except in cases where one-quarter horse power or less is used.

The motor leads or branch circuits must be designed to carry a current at least 25 per cent greater than that for which the motor is rated, in order to provide for the inevitable occasional overloading of the motor, and the increased current required in starting, without overfusing the wires, but where the wires under this rule would be overfused, in order to provide for the starting current, as in the case of many of the alternating current motors, the wires must be of such size as to be properly protected by these larger fuses.

In general, motors should preferably have no exposed live parts.

b. Must be thoroughly insulated. Where possible, should be set on base frames made from filled, hard, dry wood and raised above surrounding deck. On hoists and winches they shall be insulated from bed-plates by hard rubber, fiber or similar insulating material.

c. Shall be covered with a waterproof cover when not in use.

d. Must each be provided with a name-plate giving maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

83. Insulation Resistance.

The wiring in any vessel must test free from grounds; *i. e.*, the complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) of not less than the following:—

Up to	25	amperes	800,000	ohms.
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	50,000	"
"	800	"	25,000	"
"	1,600	"	12,500	"

All cut-outs and safety devices in place in the above.

Where lamp sockets, receptacles and electroliers, etc., are connected, one half of the above will be required.

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