RULES FOR INSTALLING ELECTRIC LIGHT AND POWER APPARATUS.

CONTAINING

"NATIONAL ELECTRICAL CODE"

OF RULES AND

NOTES ON WIRING.

INSPECTION DEPARTMENT

Associated Factory Mutual Fire Insurance Companies,

General Office, 31 MILK STREET, Room 63,

BOSTON, MASS.

FACTORY MUTUAL FIRE INSURANCE COMPANIES.

MANUFACTURERS of	*Providence,*	JOHN R. FREEMAN, Pres't.
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BOSTON MANF'RS	*Boston,*	EDW. ATKINSON, Pres't.
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APPROVED FITTINGS.

For satisfactory work, only approved fittings should be used. We print a circular, "Approved Electrical Fittings," designed to aid wiremen by showing them in advance just what will be approved.

Fittings not listed should not be used without special approval, which will be freely given on the application of members, if the device is reliable.

The approved lists are revised quarterly.

THE RULES IN BRIEF.

Designed to quickly give the busy man the general requirements for average Factory Mutual Mills.

Contracts.

We advise that all contracts for electrical work contain the following clauses: —

WORK. — All work shall be done in strict conformity to the "National Electrical Code," as given in the latest edition of "**Rules for Installing Electric Light and Power Apparatus,**" issued by the Associated Factory Mutual Fire Insurance Companies.

FITTINGS. — All fittings used shall be such as are specified in the latest edition of "**Approved Electrical Fittings,**" issued by the Associated Factory Mutual Fire Insurance Companies.

Generators.

Generators should be located in a dry, clean place, away from combustible materials, and a light rather than a dark location is always preferable. It is not desirable to place them in the work-rooms of a plant where combustible stuff abounds, as in the ordinary textile mill, though they may sometimes be so located if properly partitioned off from the main room. A location suitable for a first-class steam engine is generally none too good for a generator.

A solid foundation is necessary for smooth running. The generator frame should, where possible, rest on timber supports, and be fastened to them by lag screws or bolts which do not pass through in such a way as to electrically connect the frame with the ground. Two parallel timbers are preferable to a four-sided framework, which makes a place under the machine that is difficult to keep clean.

Motors.

Motors should, in general, be treated like generators, though often necessarily placed in work-rooms.

The induction motor of the type without brushes, having therefore no sliding contacts through which the current passes to make trouble, can be located in almost any part of a textile plant with safety, being generally no more dangerous than an ordinary machine of similar size running at the same speed.

Direct current motors, or alternating motors with brushes, should be so located or enclosed that serious sparking at the brushes could not cause a fire.

Where enclosures are necessary, they should generally be made largely of glass, so as to keep the motor in full view of the attendants, thus promoting cleanliness and making it possible to quickly discover any derangement. The enclosures must be thoroughly ventilated to prevent them getting unduly hot. The casing is looked upon as a separation between possible sparks and combustible material, and not as a fire wall.

The starting rheostat main switch and fuses should be treated about like the motor and enclosed when it is enclosed.

An ammeter is desirable with motors to show just how much load they are carrying, and will often save its cost by indicating wastes of power.

Switchboards.

Switchboards should be of slate or marble supported on metal frames, or of wood in skeleton form. They should be located well away from inflammable materials, and always open at sides and top so as to give the attendant a clear view of all the wiring. They should contain the ordinary instruments, and reliable devices for testing for grounds.

The instruments should be neatly arranged and the wiring on the back laid out in a careful and workmanlike manner.

Dynamo Room Wiring.

Wiring in the dynamo room should usually be like any other heavy inside wiring, but where the size of the plant or the number of machines is such that a good many wires come together, the insulating covering on the wire should be of a non-burnable kind, like the old "Underwriters." When rubber insulation is considered necessary, it should be covered with a thick outer "slow-burning" braid.

The weather-proof and rubber insulations in common use contain a very large amount of burnable matter, which ignites easily, and, once ignited, produces a fierce fire and a dense smoke.

The idea is to have the wire so rigidly supported on heavy insulators that if bare wire were used the insulation would be perfect. A non-burnable insulating covering is then desirable to prevent accidental short circuits. All joints should be very carefully and securely made.

An automatic sprinkler protection is not always advisable in dynamo rooms, the necessity for reducing the chances of a fire are at once evident.

Outside Wires.

All outside lines should be carefully laid out through mill yards, so as not to interfere with fire streams or ladders, a definite plan being determined upon before work is commenced. Many wiremen are very careless about this matter, and if not cautioned will run the wires in the easiest way, regardless of looks or safety.

Wherever the current enters a mill yard from a distant station, outside emergency switches should be so placed that in case of fire or other accident the current can be cut out of the yard. Telephone or call bell service from the mill to the power station is not considered reliable enough to make switches unnecessary. Where lightning disturbances are probable, suitable protection should be provided.

Fire Lights.

It is a good plan, where possible, to arrange a few lights in yards or in buildings on circuits entirely out of the way of ladders, or fire streams which may be thrown on at the time of a fire when the main lights are off, and give light enough to enable firemen to move about with quickness and safety. Such lights can generally best be arranged entirely on separate circuits, which circuits will perform ordinarily a useful work for lighting the help into and out of the mill when the main lights are off, and are also useful in repair work. They may take current from a small separate generator driven by an independent engine or water-wheel, from outside lines or possibly from storage batteries, which are so isolated from the main buildings as not to be affected by a fire in them.

Transformers.

Transformers should always be located outside of buildings, unless special permission is given to put them inside. When inside they should be so located that an internal burn-out, which might occasion a dense smoke, would not be liable to cause a water loss by being mistaken for a fire, and so that, where oil filled cases are used, the boiling over of the oil could not cause a fire.

In some cases it may be considered especially necessary for safety to life and from fire to ground the middle of the secondary coils of the transformers; or to use a transformer with a grounded shield.

Inside Wiring.

For inside work the wiring should generally be entirely in sight and supported upon porcelain knobs or cleats. Heavy mains can usually best be carried through space from timber to timber. To carry them around the beams or to carry them through is difficult. The first on account of the stiffness of the wire, the second from its size necessitating, with the bushing, a hole large enough to endanger the strength of the beam. The branch wires being usually of small size can ordinarily be carried around the beams, but are not generally strong enough to safely carry from beam to beam unless running-boards are provided. All wires coming up side wall or posts should be specially protected from mechanical injury, either by carrying them through iron pipes or by boxing. In putting up the wires, straight lines and thorough supporting, and, in general, neat workmanlike construction should be insisted upon.

Cut-outs may be either open or boxed, according to the kind used, our circular, **Approved Electrical Fittings,** specifying just how each type must be used. Switches should be kept away from contact with combustible stuff. Open knife switches, with their exposed contacts, are not generally desirable about the working rooms of a plant. They are, however, in many ways the most desirable type of switch when boxed or so located that there will be no danger of short circuits being accidentally formed across their exposed contacts from careless or thoughtless workmen. For the usual controlling of low voltage circuits, where the switches must be located anywhere about the plant, first-class snap switches are preferred.

Incandescent lamps in practically all manufacturing buildings, including those devoted to textile work, may be hung by approved flexible cords, using key or keyless sockets. Fused rosettes are considered a little better than fuseless rosettes and fewer lights per circuit. In the more hazardous parts, such as cotton napping rooms or dust chambers, picker rooms, etc., the water-proof type of construction advised for storehouses should be used.

Arc lamps located inside of buildings should in general have high globes, tight at the bottom, to prevent the escape of sparks. Wherever they are over loose combustible stuff, they should have either spark guards, in addition to the globes, or globes which are entirely tight, such as those used with the enclosed arcs. The inverted arc with large shade under it is suitable for use except in rooms where dust abounds, which would tend to collect in the shades and take fire when the lamps were started. Inverted arcs would also be undesirable in a place where there was a large amount of loose combustible stuff, such as a picker or card room.

Storehouses.

Where light is needed in storehouses, incandescent lamps are considered the best and safest arrangement. The wires may be run about as in ordinary inside work, but should be very carefully protected, so that the storage in the building could never derange them. The lamps should be hung on the water-proof plan, using water-proof sockets. The cut-outs and switches should all be grouped and enclosed in fire-proofed cabinets. The lamps themselves should either be so placed or so protected by guards that they could not come in contact with the contents of the storehouses, as an incandescent lamp will in time set fire merely from its heat.

Telephone, Call Bell, and Similar Circuits.

The arrangement of these wires should be as carefully planned as the lighting or power circuits. They should be so placed as never to be in the way of fire streams or ladders. Where possible, the private wires about the yard should be kept entirely away from lighting or power circuits, which carry dangerous currents. This entirely avoids the danger of the two systems crossing if breaks occur, and dangerous currents being conducted into buildings over wires ordinarily considered harmless.

Where the arrangement is such that crosses might occur if wires broke, protectors should be provided near the point where the wires enter the building. Protectors should always be provided on foreign lines, and on all private lines liable to lightning disturbances or dangerous crosses.

INTRODUCTION TO RULES.

"The National Electrical Code, as it is here presented, is the result of the united efforts of the various Electrical, Insurance, Architectural, and allied interests which have, 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. The following is a list of the Associations represented in the Conference, all which have approved of the Code.

American Institute of Architects.
American Institute of Electrical Engineers.
American Society of Mechanical Engineers.
American Street Railway Association.
Factory Mutual Fire Insurance Companies.
National Association of Fire Engineers.
National Board of Fire Underwriters.
National Electric Light Association.
Underwriters' National Electric Association.

Preface to Sixth Edition.

As seen from the above, uniformity in rules has at last been obtained in a most satisfactory manner. This result was brought about by much earnest work and negotiation on the part of the delegates of the above Associations who were charged with the bringing together of all those who are affected by electrical rules.

The interests of all are in a broad way identical, so that it is believed this formal co-operation will be of great mutual benefit.

The new code does not materially modify the actual requirements for factory work given in all the previous editions of the Electric Rules of the Factory Mutuals. The rules have, however, been newly classified to secure more logical arrangement, the old classifications made in the earlier days of electrical development having become generally unsatisfactory.

It is impracticable to prepare a set of rules which will wisely cover every case, and the applications of electricity are still in a state of frequent change. If, therefore, in any instance it may appear that these rules do not cover the peculiar existing conditions in the best way, we shall be ready to give it special consideration.

We have, as in our first edition, added a running commentary upon the rules, in the form of foot notes, in order to make the reason for each rule more clear, and to point out the special danger which it guards against.

To enable one not specially familiar with electrical matters, or too busy to give but a few minutes to the subject, to quickly gain an idea of the rules, we have printed next the front cover a brief abstract of the requirements applying to average Factory Mutual work.

The notes on wiring added to the rules with this edition were designed to make clear points which our inspections show are frequently not fully comprehended. They will, it is believed, be of value to all, but especially to those with limited experience in electrical work.

The notes in connection with the rules and cuts have been prepared in consultation with Professor William L. Puffer, of the Electrical Engineering Department of the Massachusetts Institute of Technology.

August, 1897.

GENERAL PLAN

GOVERNING THE ARRANGEMENT OF RULES.

CLASS A. — **Central Stations, Dynamo, Motor** and **Storage-Battery Rooms, Transformer Sub-stations, etc.** Rules 1 to 11.

CLASS B. — **Outside Work,** all systems and voltages. Rules 12 and 13.

CLASS C. — **Inside Work.** Rules 14 to 39. Subdivided as follows: —

General Rules, applying to all systems and voltages. Rules 14 to 17.

Constant-Current systems. Rules 18 to 20.

Constant-Potential systems:

All voltages. Rules 21 to 23.
Voltage not over 300. Rules 24 to 31.
Voltage between 300 and 3500. Rules 32 to 37.
Voltage over 3500. Rules 38 and 39.

CLASS D. — **Specifications for Wires** and **Fittings.** Rules 40 to 63.

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

CLASS F. — **Marine Wiring.** Rules 68 to 80 (Not printed).

The Rules are printed thus: — (Must be located in a dry place.)

The fine-print notes belonging to the National Electrical Code are in the smaller fine type, thus: —

(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, etc.)

The explanatory notes added by the Factory Mutuals are printed in the larger of the fine types, thus: —

(If generators are allowed to become wet there is likely to be more or less charring or burning of the cotton insulation of the wires, due to the fact that shellaced cotton when wet, etc.)

GENERAL SUGGESTIONS.

In all electric work conductors, however well insulated, should always be treated as bare, to the end that under no condition existing or likely to exist, can a grounding 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 insulation, except for constant current systems, the work should, if possible, be started from a centre of distribution, and the switches and cut-outs, controlling and connected with the several branches, be grouped together in a safe and easily accessible place, where they can be readily got at for attention or repairs. 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 endorsed 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, and in specifications for electric gas lighting to require a two-wire circuit, whether the building is to be wired for electric lighting or not, so that no part of the gas fixtures or gas piping be allowed to be used for the gas-lighting circuit.

RULES.

"NATIONAL ELECTRICAL CODE."

CLASS A.

STATIONS AND DYNAMO ROOMS.

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

1. **Generators.**

a. Must be located in a dry place.

If generators are allowed to become wet there is likely to be more or less charring or burning of the cotton insulation of the wires, due to the fact that shellaced cotton when wet will conduct electricity. In time the current leaking over this moist conducting path which is constantly becoming better, due to the formation of copper salts by electrolytic action, will produce undue and excessive heating, or even fusion of some of the metallic parts.

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.

Any generator is liable to produce sparks if badly designed, improperly handled, or overloaded. Such sparks are of sufficient intensity to set fire to readily inflammable gases, dust, lint, oils, and the like.

c. Must be insulated on floors or base frames, which must be kept filled to prevent absorption of moisture, and also 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 insulated 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 very high resistance of not less than 200 ohms per volt generated by the machine.

The object of the rule is to keep the generator completely insulated from the ground. By "ground" is to be understood the earth, walls or floors of masonry, pipes of any kind, iron beams and the like. A wooden base, if wet, covered with oil and metal dust, or one with the dynamo holding bolts passing entirely through it, affords an opportunity for an escape of the current to the ground. A good hard and durable finish for the frame can be made by several coats of linseed oil and a finish coat of shellac or hard varnish. The danger feared if any part of the frame of the generator is grounded is that a slight fault in the insulation of magnet or

1. **Generators.**— *Continued.*

armature coils is likely to ground the electric system, causing then a short circuit, with its accompanying dangers, the instant any other ground occurs on any part of the circuit.

It is best to provide a solid timber frame even with a wooden floor, for it is difficult to be sure that even a dry floor will furnish perfect insulation by reason of the many nails driven through it, the pipe hangers likely to be screwed into its under side, and the many other possibilities of metallic connection to the ground.

The timber frame should generally raise the generator several inches above the floor level, as it is easier to keep a raised frame surely free from metal dust, oil, dampness, etc.

When generators are coupled directly to engines or water wheels, it is necessary to use an insulating coupling if the frames are to be insulated from the ground. The insulation of such couplings is not entirely reliable, as the vibrations, shocks, and constant strain of driving, together with oil and dirt, are very liable to destroy the insulating material.

With very large and heavy generators it is often practically impossible to maintain a high insulation between the frame and the earth, using ordinary insulating material. The great weight will crush out ordinary insulating materials, spoiling the insulation and allowing the frame to get out of alignment.

With a grounded frame, the insulation of the system depends on the insulation of the dynamo conductors from the frame. If this breaks down, the system becomes grounded. The fault should, of course, be remedied at once.

The *positive* ground is required wherever frame insulation is impossible to provide a definite path for leak currents and prevent them escaping through parts of a building, etc., where they might do harm.

A good ground can be made by firmly attaching a wire to the frame and to any MAIN water pipe inside the building that is thoroughly connected with underground pipes. The wire should be securely attached to the pipe by soldering it to a brass plug screwed into a fitting, by binding it under a heavy split clamp, or by any equally thorough method. Generally, with direct coupled units, a safe enough ground would be furnished through the engine or water wheel.

d. Every constant-potential generator must be protected from excessive current by a safety fuse, or equivalent device, of approved design in each lead wire.

These devices should be placed on the machine or as near it as possible.

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

If this is not done an accident at the exposed metal parts of the switch or on the mains at the switchboard may result in a short circuit and is liable to cause the burning out of the armature.

The best place for the fuse is at the machine itself as then it can take care of all accidents outside of the machine. If it is on the switchboard, the wires between it and the machine are totally unprotected.

e. Must each be provided with a waterproof cover.

This is to protect them when at rest from water and any other falling or flying material, and tends to prevent serious damage to them if a fire anywhere causes a thorough wetting down of any rooms above them.

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

The name-plate shows exactly what the machine was designed for. Such information is often of great convenience, and also tends to prevent overrating, either from ignorance, or desire to magnify the merits of a machine to help a sale.

Ammeters and Voltmeters.

It is advised that every constant-potential generator have, in its armature circuit, a reliable ammeter, which shall be clearly marked to indicate the full load of the machine.

1. **Generators.** — *Continued.*

Ammeters are made to indicate the amount of current given out by the generator, and they show instantly if there is any undue load, such as would be produced if too many lamps were put in circuit, or if there was serious loss of current from poor insulation of wires.

It is always desirable to have an ammeter so graduated that a full scale deflection corresponds to a full load, for when several machines of different sizes are running in parallel, each machine will be doing its share of the work when the ammeter pointers are in similar position.

It is also best to provide a reliable voltameter as a fixture on a switchboard, and to have it so arranged as to show the voltage either of the dynamos, or of any other desirable part of the system, and also the voltage between the positive or negative wire and the earth, thus serving as one of the most accurate ground detectors. (See Fig. 12, page 78.)

2. **Conductors.** — From generators to switchboards, rheostats or other instruments, and thence to outside lines.

a. Must be in plain sight, or readily accessible.

So that any kind of an accident which might happen to the wires may be noticed and repairs made at once.

Such main conductors in immediate connection with the source of power must be treated as especially dangerous, because the whole capacity of the system would be concentrated in them should any arc start or accidental contact be made.

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.

(See Switchboards, pages 61 to 69, for cuts and general suggestions.)

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

To prevent short circuits, with their accompanying dangers, which are great where such large currents are available.

It is also often necessary to secure the wires against accidental and careless knocking from ladders, belts, etc., in the hands of thoughtless workmen.

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

3. **Switchboards.**

(See Switchboards, pages 61 to 69, for cuts and general suggestions.)

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, but a space of at least ten or twelve inches should be left between the floor and the board, and from eighteen to twenty-four inches 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.

Arcs are always formed when a switch carrying a current is opened, and with very large currents it sometimes happens that the entire switch may be completely melted, either by an accidentally large current or by the arc produced upon opening the switch while the current is too large.

3. **Switchboards.** — *Continued.*

Large fuses often placed on switchboards also are sources of danger, for when one opens, melted metal is sometimes thrown violently all about, also, in poorly designed fuse blocks, arcs sometimes maintain after the fuse melts, and if they hold long enough will heat the fuse blocks red-hot.

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

The object is to reduce the combustible material to a minimum.

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 wiring is on the back it must be accessible for repairs or examination. Although wiring be on the face, a free open air space at the back of the board is still desirable.

d. Must be kept free from moisture.

Water on a switchboard is liable to produce serious trouble, as it is almost certain to start arcs over the surface of all the insulating coverings and over the board itself, for water soaked insulators become imperfect conductors; moreover, a current will run over a film of water upon a non-absorptive insulator like glass, porcelain or hard rubber. This leakage current will by electrolytic action form salts of copper over the surface of the insulating parts, increasing the leakage by making them excellent conductors, and the inevitable results will be the destruction of the weakest part, be it insulation, wire, or dynamo.

Under such conditions there would be great danger of the attendant receiving severe shocks.

e. Bus bars must be equipped in accordance with rules for placing conductors.

4. **Resistance Boxes and Equalizers.**

(For construction rules, see No. 60.)

a. Must be placed on the switchboard, or, if not thereon, at a distance of a foot from combustible material, or separated therefrom by a non-inflammable, non-absorptive, insulating material.

Resistance boxes should be considered as stoves, which under some conditions may become red-hot, and from which drops of heated metal may fall, or even fly.

5. **Lightning Arresters.**

(For construction rules, see No. 63.)

a. Must be attached to each side 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.

The kind and degree of protection necessary depends largely on circumstances.

A short out-door line from one building of a mill plant to another will often require nothing, while a long overhead line through an open, exposed country will generally need the most careful engineering to secure reasonable freedom from lightning disturbances.

The most common device is the lightning arrester, which is in principle merely a spark gap, across which the high potential lightning charge will pass to a point thoroughly connected to the earth and thus reach the ground.

5. **Lightning Arresters.** — *Continued.*

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.

Station arresters should generally be placed in plain sight on the switchboard.

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

The arresters should be so accessibly located that they may be easily examined from time to time, and should always be isolated from combustibles, as sparks are produced whenever the arrester operates.

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 No. 6 B. & S. copper wire, which must be run as nearly in a straight line as possible from the arresters to the earth 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 wire from a lightning arrester be put into iron pipes, as these would tend to impede the discharge.

(See Lightning Arrester Grounds and Choke Coils, pages 70-74, for cuts and general suggestions.)

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 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.

(See Ground Detectors, pages 75-79, for cuts and general suggestions.)

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 preserved 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 insulated on floors or base frames, which 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 very high resistance of not less than 200 ohms per volt generated by the machine.

For the same reason that similar requirements were made for generators. (No. 1 *c*.)

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

The leads or branch circuits should be designed to carry a current at least fifty per cent. greater than that required by the rated capacity of the motor, to provide for the inevitable overloading of the motor at times without over-fusing the wires.

c. The 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." Where one-quarter horse-power or less is used on low-tension circuits a single-pole switch will be accepted. The switch and rheostat must be located within sight of the motor, except in such cases where special permission to locate them elsewhere is given, in writing, by the Inspection Department having jurisdiction.

The double-pole 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.

d. Must have their rheostats or starting boxes located so as to conform to the requirements of Rule 4.

In connection with motors the use of circuit breakers, automatic starting boxes and automatic under-load switches is recommended, and they *must* be used when required.

Such rheostats are generally used only while starting, and the commercial practice is to make them as small as possible, because the time required to start a motor is generally so short that the rheostat will not be dangerously heated by the starting current. Such rheostats are dangerous from a fire point of view, because if the current is allowed to flow through them too long there is excessive heating and often fusion of some part of the rheostat; it is to be noted that the safety fuses required by the motor will readily carry current enough to melt the rheostat, so that the rheostat is not protected at all by the fuses. To be safe a rheostat should have as

8. **Motors.** — *Continued.*

large a carrying capacity as the motor itself, or be so equipped with a strong spring throw attachment so that it is mechanically impossible to keep the current on it long enough to burn it out unless purposely held there.

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.

Such arrangements of motors are not allowed on account of the high voltage used with apparatus designed only for lower voltages. Moreover, in these methods of running, if one motor fails, the others may get an excessive current, with the danger of a burn-out, or severe arcing, unless protecting devices — which cannot always be relied upon — work.

f. Must be covered with a water-proof cover when not in use, and, if deemed necessary by the Inspection Department having jurisdiction, must be inclosed 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.

Casing might be advisable, if a motor were necessarily run in the vicinity of combustibles, or if in a very dustv, dirty, or wet place.

Such cases should generally have considerable glass in them 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.

For the same reasons as given under 1 *c*.

h. 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.

For the same reasons as given under 1 *f*.

9. **Railway Power Plants.**

a. Must be equipped in each feed wire before it leaves the station 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 fire-proof base, and in full view and reach of the attendant.

A magnetic circuit breaker is preferred to a safety fuse, as it acts quicker, is more reliable and can be quicker and more safely replaced.

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 applied to similar apparatus fed from dynamo generators developing the same difference of potential.

Because charged storage batteries have in them at all times a large amount of stored energy and should therefore be treated as carefully as dynamos of similar out-put.

b. Storage battery rooms must be thoroughly ventilated.

Because the action of the current in charging liberates at times large quantities of hydrogen and oxygen, making, under possible conditions, an explosive mixture that might be exploded by any accidental spark.

10. **Storage or Primary Batteries.**—*Continued.*

c. Special attention is directed to the rules for rooms where acid fumes exist. (See No. 24 *j* and *k*.)

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

For the same reason that dynamos are insulated; wood, however, will not stand the acid and water freely used about storage batteries, so that either glass or porcelain insulators of special design are used.

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

Because the ordinary currents in use might easily burn out a connection reduced in area by corrosion.

11. **Transformers.**

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

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, a dense smoke may be produced and, with oil filled cases, heat enough may be developed to boil over the oil and perhaps set it on fire. The smoke, though not likely to cause a fire, is apt to be mistaken for one. Water is thrown on, and a heavy water loss may follow.

Class B.

OUTSIDE WORK.

All Systems and Voltages.

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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 No. 41 and 44.) All tie wires must have an insulation equal to that of the conductors they confine.

In factories having private plants, the yard wires running from building to building are not generally considered as service wires, so that rubber insulation would not be required where entering buildings when not required for all of the inside work. The requirement for rubber services was specially aimed at taps from public lines often with great capacity behind them, so that the very best wire is desirable.

Bare line wires will, of course, be permitted through uninhabited and isolated territories free from all other wires, as in such places wire covering would be of no use as it is not relied on for insulation and is not needed for other purposes.

The object of insulating the wires is to insure against trouble produced by an accidental contact of two wires. High-grade rubber insulating covering for the wires is not demanded, because the permanent insulation of the wires from the ground is assured by the glass or porcelain insulators to which the wires are secured. A mechanically strong and durable covering is required to prevent actual metallic contact between the wires themselves or any foreign wire.

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. Service blocks must be covered over their entire surface with at least two coats of waterproof paint.

To prevent water from forming a short circuit, as well as to guard against actual contact produced by the swaying of the wires by the wind.

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.

So that men can walk on the roofs without danger; and, also, so that under no conditions could they sag and touch the roof.

d. Must be protected by dead insulated guard iron or wires from possibility of contact with other conducting wires or substances to which current may leak. Special precautions of this kind must be taken where sharp angles occur, or where any wires might possibly come in contact with electric light or power wires.

The guard irons prevent the wire from falling any distance should the insulator pin give way or the insulator be broken.

The guard wires prevent the wire from coming in contact with other wires should they break and fall on them.

12. **Wires.** — *Continued.*

Other wires over which high potential wires may be strung should in turn be provided with guard wires.

It is specially desirable when arranging wires in mill yards to avoid, in every possible case, crossing other wires, either under or over them. Crosses, when unavoidable, should be made nearly at right angles, and the under wires should be protected by strong guard wires.

If this is not done, the breaking or sagging of a wire may result in contacts which could send currents over the other wires sufficient to cause fire and often endanger life.

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

The surface of porcelain knobs or cleats is not free from moisture during a rain, and they are, therefore, practically of no use as an insulator in wet weather. The petticoat insulator will nearly always have a dry space underneath its umbrella-like lower edge, and even if not dry the length of the path offered to an escaping current is very great.

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.

A poor joint offers great resistance and causes, consequently, much heating, the result often being a complete burning off of the wire. A good mechanical joint is required for strength should the soldering give way or become corroded by traces of acid used in soldering.

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.

(See Bushings, pages 80-81, for cuts and general suggestions.)

h. Telegraph, Telephone and similar wires must not be placed on the same cross-arm with electric light or power wires.

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

Trolley Wires.

j. Must not be smaller than No. 0 B. & S. copper or No. 4 B. & S. 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.

This rule applies principally to street railways.

Trolley Wires. — *Continued.*

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.

In Factory Mutual work trolley wires must not be carried into buildings until special permission has been given and the best method of running and protecting the wires decided upon.

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.

13. **Transformers.**

(For construction rules, see No. 62.)

a. Must not be placed inside of any building, excepting central 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*, because if the insulation in the transformer breaks down a dense smoke may be produced and with oil filled cases heat enough may be developed to boil over the oil and perhaps set it on fire.

The smoke though not likely to cause a fire is apt to be mistaken for one, so that water is turned on and a heavy water loss perhaps entailed.

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

In previous editions it has been specifically required that transformers with low potential secondaries (300 volts and under) should have the middle of the secondary coils of the transformers thoroughly grounded, or that an approved grounded shield should be used.

This requirement has been omitted from this edition solely for the sake of uniformity in rules.

The grounding of the secondary or the use of an approved grounded shield will, however, be required when considered especially necessary for safety to life, or from fire.

If the primary and secondary coils of a transformer come into contact electrically, the high voltage primary current may flow to the secondary system, which is entirely unsuited to safely handle such high voltages. The result is apt to be arcs to ground, perhaps causing fires, together with great danger to life for one handling any part of the secondary system.

The grounded shield is generally a copper plate coming between the primary and secondary coils at every point, so that if the insulation of either coil breaks down, the current is shunted to the ground through the shield, and the chances of the dangerous high voltage current reaching

13. **Transformers.** — *Continued.*

the secondary wiring become very small. Grounding the middle of the secondary coil accomplishes the same result in a way that is absolutely reliable if a thorough ground connection is made, for, though the high voltage current reaches the secondary wiring, there cannot be any dangerous difference of potential between the secondary system and the ground.

The *middle* of the secondary coil is the best point to ground, as then there is only half the normal secondary voltage between either side and the ground, thus reducing the liability of a breakdown of insulation and also materially lessening the danger if a breakdown does occur.

There is an objection in grounding the secondary, for, when this is done, the first breakdown of insulation may mean a short circuit, and a possible fire. With a system free from grounds two breakdowns must occur before the short circuit, and with proper ground detectors the first should be discovered and remedied before the second occurred. Grounding is therefore a choice of evils, but in many cases is believed a lesser one than to have a high voltage primary current get on to the secondary system.

When a ground is made for shields or secondaries a good one is specially necessary. The general ideas for grounds given on pages 70–74 should be followed. It would, however, be proper to make connection in this case to any **main** water-pipe inside a building that was thoroughly connected to underground pipes. The wire should be securely attached to the pipe by soldering it to a brass plug screwed into a fitting, by binding it under a heavy split clamp, or by any equally thorough method.

CLASS C.

INSIDE WORK.

All Systems and Voltages.

GENERAL RULES—ALL SYSTEMS AND VOLTAGES.

14. **Wires.**

(For special rules, see Nos. 18, 24, 32, 38 and 39.)

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

It has been found by experience that wires smaller than the sizes mentioned are not mechanically strong enough to be safely used.

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

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

Stranded wires must be soldered before being fastened under clamps or binding screws, and, when they have a conductivity greater than No. 10 B. & S. copper wire, they must be soldered into lugs.

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.

A poor joint offers much resistance and causes, consequently, much heating, the result often being a complete burning off of the wire. An arc would then play between the ends, certainly a dangerous thing for inside wires.

Connections by clamps, screws, etc., are not reliable. All of the strands cannot generally be thoroughly connected, and consequently the load is thrown on a part of them. Undesirable heating may consequently occur.

d. Must be separated from contact with walls, floors, timbers or partitions through which they may pass by non-combustible, non-absorptive insulating tubes, such as glass or porcelain.

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, which may be a conductor, such as iron pipe; the tube then is to have a non-conducting bushing pushed in at each end so as to keep the wire absolutely out of contact with the conducting pipe.

(See Bushings, pages 80 and 81, for cuts and general suggestions.)

14. **Wires.**— *Continued.*

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 separation of at least one inch. Deviations from this rule may sometimes be allowed by special permission.

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.

To prevent the water, which is apt to collect on the outside of such pipes, making contact between the pipes and the wire, or by dropping on the wires, then running along to and over the insulators and causing a leak by connecting the wires to the building over wet surfaces. If all pipes are underneath the wires no dropping water can possibly make a contact.

15. Underground Conductors.

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

There being often no safety fuses for such underground wires a contact between wires, or between the wires and the ground, would result in serious arcing and perhaps even the wires would be melted.

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

16. Table of Carrying Capacity of Wires—

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

B. & S. G.	Table A. Rubber-covered Wires. See No. 41. Amperes.	Table B. Weather-proof Wires. See No. 42-44. Amperes.	Circular Mills.
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

16. **Table of Carrying Capacity of Wires.** — *Continued.*

Circular Mills.

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 sixteen and eighteen wire is given, but no smaller than fourteen is to be used, except as allowed under Rules 24 *t* and 45 *b*.

There is a general agreement of those familiar with the effect of heat on rubber, that, if long life is desired, the temperature should not exceed 150° F.

In 1889, Mr. A. E. Kennelly made an elaborate series of careful experiments at the Edison Laboratory to determine the temperature rise in wires under different conditions, caused by various currents.

The currents given in Table A are about 60 per cent. of the currents which Mr. Kennelly found caused a rise of 75° F., or a final temperature of about 150° F., assuming 75° F. as the average indoor temperature, This margin of 40% is to allow for inevitable increase of current, such as that produced by the changing from one size lamp to those of a larger candle-power, the adding of more lamps to a circuit, the overloading of a motor, etc. The currents given in Table A cause a rise of temperature of about 29° F. above the surroundings, but varying somewhat with the size of the wire. It is well to remember in this connection that the heating effect increases about as the square of the current, *i. e.*, if the current is double, the heating effect increases four times.

The limiting temperature for weather-proof insulation is about the same as for rubber, but the currents given in Table B are larger than A, because in this class of wire the covering is not relied on for insulation, but rather for mechanical protection, the electrical insulation being secured by the porcelain or glass supports to which the wire is attached. Under these conditions a lesser factor of safety may be allowable, so that Table B has been taken as about 90% of the 150° currents, allowing, therefore, but a small margin.

It is interesting to note that about three times Table A cause all ordinary insulations to begin to smoke.

Owing to the cooling effect of air currents, the safe-carrying capacity of outdoor conductors may be several times greater than the above, without causing any dangerous rise of temperature. As the conditions will vary so widely, and such outdoor conductors are not at all liable to cause fire, no table has been made for them.

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

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

a. Must, whenever called for, 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 the switch or circuit breakers 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.

It is much safer to have a circuit absolutely disconnected from the source of current when the safety devices operate or switches are open. Otherwise short circuits might be made or shocks received, especially if the system was grounded.

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

Cut-outs and circuit breakers are designed to prevent the fusion of wires in which they are inserted by locating the inevitable fusion of something if too heavy currents are thrown on the wires in a place specially designed to withstand it. Many of them make a considerable flash and sometimes throw out globules of melted metal when they operate, thus making necessary isolation from combustible stuff.

Switches may also cause flashes when opened, and therefore need to be safely located.

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

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.)

The high voltages generally employed make it desirable to have the very best insulation.

b. Must be arranged to enter and leave the building through an *approved* double-contact service switch (see No. 51), mounted in a non-combustible case, kept free from moisture, and easy of access to police or firemen. So-called "snap switches" must not be used on high-potential circuits.

This is to make it possible to cut the high voltage current entirely out of a building in case of fire. The switch is also necessary when work is to be done on the inside wires.

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

On account of the high voltages generally used, it is considered safer to have the wires where they can be under constant inspection.

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

18. **Wires.**— *Continued.*

each other, except within the structure of lamps, on hanger-boards, in cut-out boxes, or like places, where a less distance is necessary.

The idea is to so rigidly secure the wires that they cannot come in contact with each other or anything else.

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.

For methods of boxing, see Protecting Boxes, pages 71, 72 and 73, and for running boards, see Fig. 32, page 90.

19. **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, securely fastened upon a closed base. No broken or cracked globes to be used.

Arc lamps are always liable to throw off sparks, hot bits of carbon or even the entire red-hot carbon itself. The globe is supposed to prevent the escape of such hot particles.

c. Must be provided with a wire netting (having a mesh not exceeding one and one-quarter 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, melted copper or carbon. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

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

For the present, globes and spark arresters will not be required on so-called "inverted arc" lamps, but this type of lamp must not be used where exposed to flyings of easily inflammable materials.

The objection made to copper-plated carbons is due to the fact that as the carbons burn away, the copper, not being consumed, collects in melted globules, which fall from time to time.

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

The conducting wires are not properly supports. Firmer joints and a generally safer arrangement is secured where the wires are independent of the supports.

20. **Incandescent Lamps in Series Circuits.**

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

As such lamps on the same circuit with the arcs are equally dangerous in all electrical points, they should be installed with equal care, but of course no provision need be made for hot particles of carbon or sparks.

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

To prevent the wires from swinging into contact with objects near at hand, and to prevent possibility of breaking of the wire, from constant bending or loosening of the screws holding the wire in place. See Fig. 36, page 106.

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

Experience has shown that magnetic devices become rusty or filled with dust, and often fail when wanted.

Both multiple-series and series-multiple systems of lighting were once used, but gave a good deal of trouble and proved themselves generally unreliable.

d. Under no circumstances can they be attached to gas fixtures.

Because of the dangerous proximity between the high voltage circuit and a pipe which is thoroughly connected to the ground.

CONSTANT-POTENTIAL SYSTEMS.

General Rules—All Voltages.

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

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

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

In factories 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, if the entering mains are so protected as to fully take care of the entering wire.

The purpose of such cut-outs is to make sure that the wires inside a building cannot be subjected to a current larger than they can safely carry. They are absolutely necessary when taking current from the public plant, as the fuses in the mains are often changed without regard to the wiring in the buildings.

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).

21. **Automatic Cut-outs.** — *Continued.*

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

Many cut-outs make a considerable external flash when a fuse melts, so that boxing is often necessary for safety. Such rooms as a cotton picker room or card room, a cloth napping room, a wood-working department, and in fact most of the rooms in textile mills of any kind contain enough inflammable stuff to make cut-outs, in which the fuse is not so *tightly* enclosed that if the cut-out were covered with such stuff as cotton lint it could blow without igniting the cotton, unsafe unless boxed.

(See Fig. 27 and description, page 95, for suggestions on boxes. Also, see Figs. 28, 30 and 31.)

d. Must be so placed that no set of incandescent lamps, whether grouped on one fixture or several fixtures or pendants, requiring more than 660 watts shall 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 case of large chandeliers, stage borders and illuminated signs.

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.

Fused rosettes used with flexible cord pendants are of course considered the equivalent of a cut-out.

With fused rosettes, however, the branch circuits should be arranged so as not to require over twenty-five ampere fuses, as, if a rosette fails, it is best to have a reasonably small fuse behind it.

e. Must be provided with fuses, the rated capacity of which does not exceed the allowable carrying capacity of the wire, and, when circuit breakers are used, they must not be set more than about thirty per cent. above the allowable carrying capacity of the wire, unless a fusible cut-out is also installed in the circuit (see No. 16).

Over-fusing is a common fault and is unnecessary with well-made fuses, as there is enough margin between the rating and the melting point to take care of the ordinary fluctuations of the current.

Circuit breakers open so easily that it is often necessary to set them much above the ordinary current to keep them from constantly opening. When this is the case, a fuse is necessary to protect the wire from a steady heavy current below the opening point of the circuit breaker. The fuse requires a little time to heat, so does not melt with the momentary rises of current which would open the circuit breaker if set as low as necessary to protect the wire.

22. **Switches.**

(See No. 17, and for construction No. 51.)

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.

In factories 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 when there were switches on the mains conveniently located, or when the generators were near at hand.

The purpose of such switches is to make sure that current can be cut off from the inside wires for repairs or in case of fire or other accident. They are, of course, absolutely necessary when taking current from public lines.

See Fig. 8, page 72, and notes, pages 72-74, for best arrangement of switches in various cases.

22. **Switches.**—*Continued.*

b. Must always be placed in dry, accessible places, and be grouped as far as possible. Knife switches must be so placed that gravity will tend to open rather than close the switch.

When in rooms containing inflammable stuff, open jack-knife switches should generally be enclosed in fire-proofed boxes. Such switches make a flash when they are opened and also present possibilities of short circuits across their exposed metal parts.

It is not desirable to have switches scattered about at random. It is easier and cheaper to install them properly if grouped, and also, when grouped they can be better cared for. If jack-knife switches are not placed so gravity tends to open them, weakening or breaking of the spring may allow them to partly close, causing arcs and burning.

c. Must not be single-pole, except when the circuits which they control supply not more than six 16 candle-power lamps or their equivalent.

Double-pole switches are always preferable to single-pole, as they absolutely disconnect the part of the system out of use, not having it connected by one side, as is the case with single-pole switches.

d. Where flush switches are used, whether with conduit systems or not, the switches must be enclosed in boxes constructed of or lined with fire resisting material. 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.

23. **Electric Heaters.**

a. Must, if stationary, be placed in a safe situation, isolated from inflammable materials and be treated as sources of heat.

b. Must each have a cut-out and *indicating* switch (see No. 17 *a*).

c. Must have the attachments of feed wires to the heaters in plain sight, easily accessible and protected from interference, accidental or otherwise.

d. The flexible conductors for portable apparatus, such as irons, etc., must have an *approved* insulating covering (see No. 45 *h*).

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

Stationary heaters should be treated like stoves which might become overheated at any time.

Portable heaters, such as flat-irons, have this danger, that if left standing with the current on they in time accumulate heat enough to char combustible stuff and to finally set it on fire.

Special care should be taken in arranging circuits for portable heaters to have switches so located that any department not in operation can have the current cut entirely out of it. Current should of course be cut off from all lines at night when work stops.

A lamp in circuit with the heaters is often convenient to draw attention to the position of the switch.

LOW-POTENTIAL SYSTEMS.

300 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 300 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.

24. Wires.

General Rules.

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

a. Must not be laid in plaster, cement or similar finish.

Fresh plaster and cements may be either alkaline or acid, and until finally set have a corrosive action on the insulating materials of the wires. The amount of such alkaline or acid action is sometimes only sufficient to injure the surface of the insulation, but more often it will not only destroy the insulation, but injure the wire itself.

b. Must never be fastened with staples.

A staple driven over a wire will almost always cut a hole in the insulation, or even crack the wire itself, making a bad contact which may develop heat enough to set fire to the insulation.

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.

It is desirable to do as little fishing as possible, as the condition of the fished wires is always somewhat uncertain.

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

A twin wire is made up by placing two separately insulated wires under the same insulating covering. They are unsafe for light or power work on account of the short distance between them, and the readiness with which an arc starting at one end will follow along the wire.

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.

Suitable protection on side walls may be secured by a substantial boxing, retaining an air space of one inch around the conductor, 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 it will be subjected to; or plain metal pipe, lined with insulating tubing, which must extend one-half inch beyond the end of the metal tube.

The pipe must extend not less than five feet above the floor, and may extend through the floor in place of a floor bushing.

If iron pipes are used with alternating currents, the two or more wires of a circuit *must* be placed in the same conduit. In this case the insulation of

24. **Wires.**—*Continued.*

each wire must be reinforced by a tough conduit tubing projecting beyond the ends of the iron pipe at least two inches.

(For cuts and general suggestions on protection, see pages 82, 83, 84.)

f. When run immediately under roofs or in proximity to watertanks or pipes will be considered as exposed to moisture.

Because there is liable to be more or less water leaking through the roof, or else formed by condensation on the inside.

Special Rules.

For open work.

In Dry Places:

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

A slow-burning weather-proof covering is considered good enough where wire is entirely on insulating supports. Its main object is to prevent the wires coming accidentally in contact with each other or anything else.

In Factory Mutual work *special permission in writing* will be given for using "slow-burning" wires where, on account of excessive heat or other special reasons, this type of wire is preferable.

h. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one-half inch from the surface wired over, and they must be kept apart at least two and one-half inches.

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. wire or over, where not liable to be disturbed, may be separated about four 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 a three-wire system in the centre of a a three-wire cleat, provided the outside wires are separated two and one-half inches.

The proper distance between insulators depends largely on the surroundings. In places where ceilings are low, or where belts, shafting or other machinery may require frequent attention, insulators may have to be placed every few feet to prevent the wires getting out of place by careless and unavoidable knocking. Again, with a high ceiling and no chance for derangement, a greater distance would be allowable.

The whole idea is, to so rigidly secure the wires that they cannot come in contact when loosened by shrinkage of timbers and floors, or by careless knocking.

In damp places, such as Breweries, Sugar Houses, Packing Houses, Stables, Dye Houses, Paper or Pulp Mills, or buildings specially liable to moisture or acid or other fumes liable to injure the wires or their insulation, except where used for pendants:

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

j. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one inch

24. **Wires.** — *Continued.*

from the surface wired over, and they must be kept apart at least two and one-half inches.

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. wire or over, where not liable to be disturbed, may be separated about four inches and run from timber to timber, not breaking around, and may be supported at each timber only.

k. Must have no joints or splices.

It is difficult to tape a joint so that its insulation will be as good as the remainder of the wire.

For moulding work.

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

Rubber insulation is necessary to prevent leakage of current, if the moulding should become damp.

m. Must never be placed in moulding in concealed or damp places.

For fear that water may soak into the wood and cause leakage of current between the wires, burning the wood and starting a fire which would not be immediately discovered. The action of the current in a case like this is to very gradually convert the wood into charcoal, then dry the water out, and then ignite the charcoal.

It is to be understood that the sole object of the moulding is to furnish a convenient and fairly good-looking run-way for the wires in which they are protected from mechanical injury. Nails used for fastening on the cover must be very carefully driven, so as to avoid injuring the insulation, and ought never to be used to hold the wires in the grooves.

For conduit work.

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

The best insulation is necessary here, as the lining of the conduit has generally little permanent insulating power and may be omitted entirely. Moreover, dampness is always a possibility in a conduit.

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

This makes it absolutely necessary that the conduit should be complete from one junction box to another, and that all joints be carefully made. If wires were laid in the conduits as they were installed, it would be very easy to neglect these points.

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 system also, so that they may be changed to alternating systems at any time, induction troubles preventing such a change unless this construction is followed.

With alternating systems, if the wires of a circuit are in different iron conduits, there will be trouble from inductive losses, and under certain conditions the conduits may become seriously heated.

24. **Wires**, — *Continued.*

The trouble becomes much less if the wires are pulled into the same conduit, less still if the wires be simply twisted together, and quite disappears if concentric wire is used.

For concealed knob and tube work.

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

In concealed work, the condition of the wire is often unknown, so that the best insulation is necessary for safety.

r. 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 at least ten inches apart, and, when possible, should be run singly on separate timbers or studding.

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.

s. When from the nature of the case it is impossible to place concealed wiring on non-combustible insulating supports of glass or porcelain an *approved* armored cable (single or twin conductors, see No. 48) may be used if it is installed withou joints between outlets, and the cable armor properly enters all fittings and is rigidly secured in place; or, if the wires are not exposed to moisture they may be fished on the loop system if separately encased throughout in approved flexible tubing or conduits.

Fishing under floors or in walls is done by boring holes at suitable distances apart and pushing a flat spring wire from one hole towards the other and catching it with a wire hook. The wire to be fished is attached to the end of the spring wire and pulled into place. There can, of course, be no assurance that such fished wires do not lie in close contact with gas, water-pipes, or other wires, therefore the need of the protecting conduit.

For fixture work.

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

The wire covering lies in contact with the metal of the fixture, so that a first-class insulator, like rubber, is necessary.

It is very undesirable to use such small wires as these, as they have but little mechanical strength and are easily broken by vibration of the fixture when in place. These sizes are only to be used in places where it is absolutely impossible to put a larger and safer wire.

u. Supply conductors, and especially the splices to fixture wires, must be kept clear of the grounded part of gas pipes, and, where shells are used, the latter must be constructed in a manner affording sufficient area to allow this requirement.

v. 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.

The special object here is to prevent accidental contact between the wires and the ground.

25. Interior Conduits.

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

By interior conduits is generally understood metal tubes or pipes through which ordinary insulated wires are run.

The object of a tube or conduit is to facilitate the insertion or extraction of the conductors to protect them from mechanical injury and, as far as possible, from moisture. 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. (If conduit is lined, measurement to be taken inside of lining.)

Smaller conduits were found in practice to make so close a fit that the wires could not readily be drawn in or out.

b. Must be continuous from one junction box to another, or to fixtures, and the conduit tube must properly enter all fittings.

They must be continuous to ensure that the wire is protected its whole length.

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

This is to insure that old wires can be drawn out and new ones drawn in at any time.

d. Must be equipped at every outlet with an approved outlet box.

e. Metal conduits, where they enter junction boxes, and at all other outlets, etc., must be fitted with a capping of approved insulating material, fitted so as to protect wire from abrasion.

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

The conduit is sure to be more or less grounded, and a *positive* ground is required here for the same reasons that a positive ground was required for generator frames. See last paragraph under *c.*

26. Fixtures.

(See also No. 24 t to v.)

a. Must, when supported from the gas piping of a building, be insulated from the gas-pipe system by means of *approved* insulating joints (see No. 59) placed as close as possible to the ceiling.

It is recommended that the gas outlet pipe be protected above the insulating joint by a non-combustible, non-absorptive insulating tube, having a flange at the lower end where it comes in contact with the insulating joint; and that, where outlet tubes are used, they be of sufficient length to extend below the insulating joint, and that they be so secured that they will not be pushed back when the canopy is put in place. Where iron ceilings are used, care must be taken to see that the canopy is thoroughly and permanently insulated from the ceiling.

If wires carrying current to incandescent lights on gas fixtures must be used, it is absolutely necessary to pay particular attention to the insulation between the wires and the ground. As the available space is small the wire insulation cannot be very thick, so that this can best be done by using what is called an insulating joint, at the top of the gas-pipe, insulating the fixture in the room from the main pipe. This joint is made by interposing what is, in effect, a piece of gas-pipe made of an insulating material like hard rubber or porcelain.

26. **Fixtures.**—*Continued.*

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

Because such very sharp edges are liable to cut and tear the insulations of the wire when it is drawn into the fixture, or, in time, by mechanical jarring of the fixture in position.

c. The tendency to condensation within the pipes should be guarded against by sealing the upper end of the fixture.

The reason for sealing the upper end is, because, if the lower end is open, the heavy, moist air will fall out, leaving always the lighter, dry air inside.

d. No combination fixture in which the conductors are concealed in a space less than one-fourth inch between the inside pipe and the outside casing will be approved.

This space is necessary to allow for the thickness of insulation required in order to properly insulate the wire.

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

f. Ceiling blocks for fixtures should be made of insulating material; if not, the wires in passing through the plate must be surrounded with non-combustible, non-absorptive, insulating material, such as glass or porcelain.

27. **Sockets.**

(For construction rules, see No. 55.)

a. In rooms where inflammable gases may exist the incandescent lamp and the socket must be inclosed 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.

(See Fig. 36, page 106, for suggestions.)

When a lamp is turned out by a key socket a small spark is always produced of sufficient intensity to ignite such gases, and if the lamp itself breaks while burning, the hot filament is liable to set fire to the gas.

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

When waterproof sockets are used, they should be hung by separate stranded rubber-covered wires, not smaller than No. 14 B. & S., which should preferably be twisted together when the drop is over three feet. These wires should be soldered direct to the circuit wires, but supported independently of them.

(See Figs. 33, 34 and 35, pages 103, 104 and 105, for suggestions.)

28. **Flexible Cord.**

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

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

They are not mechanically strong enough to safely sustain much weight.

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

28. **Flexible Cord.** — *Continued.*

In flexible cords the wires of opposite polarity are brought very near together, so that the chances for short circuits are great. It is not an uncommon thing for one or more of the fine wires to break and the loose end to penetrate the insulation and form a short circuit with the other wire.

The arc formed at the instant the short circuit occurs is apt to set fire to the insulation of the wire if it be at all of a combustible nature. This will sometimes occur even if the circuit be instantly opened by melting of the fuses.

It is for these reasons that it is desirable to limit the use of cord to those places where nothing else will do.

d. Must not be used in show windows.

Because of the ease with which a defective cord will set fire to the inflammable material about it, and records show an unfortunately large number of fires caused by the common flexible cord in windows.

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

The sockets as ordinarily made have the hole through which the wire must enter threaded. The rough edges would soon cut through the insulation of the cord and cause a short circuit were it not for the bushings. Frayed cord is undesirable, as the fraying tends to continue up the cord. The frayed ends also take fire very readily.

f. Must be so suspended that the entire weight of the socket and lamp will be borne by knots 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.

The electrical connection, which is generally made by clamping the fine wires under a flat-headed screw, has not sufficient mechanical strength, and should not be trusted as a means of sustaining the weight of the lamp and fittings.

It is a good practice also to have the ends going under binding screws dipped in melted solder.

This binds the fine wires together and prevents a loose end from coming in contact with parts of the sockets, etc., and producing a short circuit.

29. **Arc Lights on Low-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 over-fusing the wires.

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

These resistances are uncomfortably warm to the hand when the lamp is burning properly, and may be melted by excessive current if the lamps fail to burn as they should.

c. Must be supplied with globes, and protected by spark arresters and wire netting around globe, as in the case of arc lights on high-potential circuits. (See Nos. 19 and 58.)

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 in general to be treated like sources of heat.

31. Decorative Series Lamps.

a. Incandescent lamps run in series shall not be used for decorative purposes inside of buildings, except by special permission in writing from the Inspection Department having jurisdiction.

HIGH-POTENTIAL SYSTEMS.

(300 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 300 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 300 volts or less.

32. Wires—

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

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

In Factory Mutual work, *special permission in writing* will be given for using "slow burning weatherproof" and "slow burning" wires for voltages not over 750 where the conditions are favorable. The "slow-burning" insulation is about the same as the old Underwriters'.

Favorable conditions would mean, besides the absence of some special reason making rubber insulation preferable, thoroughly dry surroundings and wires so located that the ordinary workman, while going about his regular work, would not be likely to come in contact with them.

In the class of *factory* work to which this exception to the rule applies, the wires are entirely on insulators, are in plain sight, and so thoroughly out of the way that the higher grade of insulation is not always a necessity.

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

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 apart at least four inches for voltages up to 750 and at least eight inches for voltages over 750.

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.

32. **Wires.** — *Continued.*

In buildings of mill construction, mains of No. 8 B. & S. wire or over, where not liable to be disturbed, may be separated about six inches for voltages up to 750 and about ten inches for voltages above 750; and run from timber to timber, not breaking around, and may be supported at each timber only.

The proper distance between insulators depends largely on the surroundings. In places where ceilings are low, or where belts, shafting, or other machinery may require frequent attention, insulators may have to be placed every few feet to prevent them getting together or otherwise out of place by careless and unavoidable knocking. Again, with a high ceiling, and no chance for derangement, a greater distance would be allowable.

The whole idea is, to so rigidly secure the wires that they cannot come in contact when loosened by shrinkage of timbers and floors, or by careless knocking.

The covering of the wires should not be depended on for insulation. The wires should be so supported on the glass or porcelain insulators that, if bare wire were used, the insulation would still be excellent. The office of the covering will then be chiefly to protect the wires from accidental contacts of any kind.

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 cuts and general suggestions on protection, see pages 82, 83 and 84.)

33. **Transformers** (When permitted inside buildings, see No. 13.) —

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

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

This is to reduce the amount of high voltage primary wire in the building to as small an amount as possible.

b. Must be placed in an enclosure constructed of or lined with 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 persons.

c. Must be effectually insulated from the ground, and the enclosure in which they are placed must be practically air tight, except that it shall 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.

See also notes under No. 13 *b*.
The object of the enclosure is to avoid the dangers outlined in No. 13 *a*.

34. **Car Wiring** —

a. Must be always run out of reach of the passengers, and must have an *approved* rubber insulating covering. (See No. 41.)

35. **Car Houses**—

a. Must have the trolley wires securely supported on insulating hangers.

b. Must have the trolley hangers 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 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 same is not in use or the road not in operation.

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

e. Must have all wiring and apparatus installed in accordance with rules under Class "C" for constant potential systems.

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

g. Must have the rails bonded at each joint with not less than No. 2 B. & S. annealed copper wire; also a supplementary wire to be run for each track.

h. Must not have cars left with trolley in electrical connection with the trolley wire.

36. **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.**

Lighting from trolley wires is forbidden because of the danger of introducing into a building a high potential circuit (generally 500 volts) which has so much capacity back of it and which is thoroughly connected with the earth on one side. Lighting from lower voltage trolley wires is also forbidden on account of the ground connection.

37. **Series Lamps**—

a. No system of multiple-series or series-multiple for light or power will be approved.

Both systems have been more or less used, but have proved themselves generally unreliable. The trouble comes, *first*, from the fittings, which are not designed for the high voltages, and *second*, from the large currents which may flow if one or more lamps or motors fail, tending to burn out parts of the apparatus.

37. **Series Lamps.** — *Continued.*

b. Under no circumstances can lamps be attached to gas fixtures.

Because of the dangerous proximity between the high voltage circuit and a pipe which is thoroughly connected to the ground.

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 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, unless the primary wires are entirely underground.

The presence of wires carrying a current at a potential of over 3,500 volts in the streets of cities and towns is considered as increasing the fire hazard.

In Factory Mutual work this requirement will be waived where a safe arrangement of the primary wires can be made and suitable protection for the secondaries provided. Each such case should be treated on its own merits.

CLASS D.

FITTINGS, MATERIALS AND DETAILS OF CONSTRUCTION.*

All Systems and Voltages.

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 2/1000 of an inch less than the specified size.

b. Wires and cables of all kinds designed to meet the following specifications must be plainly tagged or marked as follows:

1st. The maximum voltage at which the wire is designed to be used.

2d. The words "National Electrical Code Standard."

3d. Name of the manufacturing company and, if desired, trade name of the wire.

4th. Month and year when manufactured.

41. **Rubber-Covered.**

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 be of a thickness not less than that given in the following table for B. & S. gauge sizes:

From	18 to	16,	inclusive,	1/32"
"	14 to	8,	"	3/64"
"	7 to	2,	"	1/16"
"	1 to	0000,	"	5/64"
"	0000 to	500,000,	C. M.	3/32"
"	500,000 to	1,000,000,	"	7/64"
Larger than		1,000,000,	"	1/8"

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

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* In preparing Class D, the Underwriters have, from the beginning, received valuable aid from the manufacturers interested in the various fittings, and of late there have been several important examples of this co-operation. In December, 1898, a special committee met the leading socket manufacturers and agreed on a complete set of specifications. In January, 1899, another committee assembled in Chicago and discussed for several days, with representatives of the leading insulated wire manufacturers in the United States and Canada, specifications for insulations of various kinds and reached easily satisfactory agreements.

In other lines, by correspondence and conference similar beneficial co-operation has been secured, and a number of matters are now undergoing such consideration.

41. Rubber-covered.—*Continued.*

c. The completed coverings must show an insulation resistance of at least 100 megohms per mile during thirty days' immersion in water at 70 degrees F.

d. Each foot of the completed covering must show a dielectric strength sufficient to resist throughout five minutes the application of an E. M. F. of 3,000 volts per 1/64-inch thickness of insulation under the following conditions:—

The source of alternating E. M. F. shall be a transformer of at least one kilowatt capacity. The application of the E. M. F. 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 for seventy-two hours in water, one foot of which is 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 walls must not be less than those given in the following table for B. & S. gauge sizes:

From 14 to 1, inclusive,	3/32"	
From 0 to 500,000, C. M.,	3/32",	covered by a tape or a braid.
Larger than 500,000, "	4/32",	" " "

f. The requirements as to insulation and break-down 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 shall have an insulating wall not less than 6/32" in thickness, and shall withstand a breakdown test of at least 30,000 volts and have an insulation of at least 500 megohms per mile.

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 and sufficiently strong to withstand all the abrasion

41. **Rubber-covered.**— *Continued.*

likely to be met with in practice, and sufficiently elastic to permit all wires smaller than No. 7 B. & S. gauge to be bent around a cylinder with twice the diameter of the wire, without injury to the braid.

42. **Slow-burning Weather-Proof.**

a. The insulation shall consist of two coatings, the inner one to be fire-proof in character, the outer to be weather-proof. The inner fire-proof coating must comprise at least six-tenths of the total thickness of the wall. The completed covering must be of a thickness not less than that given in the following table for B. & S. gauge sizes:—

From	14 to	8,	inclusive,	3/64"
"	7 to	2,	"	1/16"
"	2 to	0000,	"	5/64"
"	0000 to	500,000,	C. M.,	3/32"
"	500,000 to	1,000,000,	"	7/64"
Larger than		1,000,000,	"	1/8"

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

b. The inner fire-proof coating shall be layers of cotton or other thread, the outer one of which must be braided. All the interstices of these layers are to be filled with the fire-proofing compound. This is to be material whose solid constituent is not susceptible to moisture, and which will 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 degrees F. and which will not burn at even higher temperature.

c. The weather-proof coating shall be a stout braid thoroughly saturated with a dense moisture-proof compound thoroughly slicked down, applied in such manner as to drive any atmospheric moisture from the cotton braiding, thereby securing a covering to a great degree water-proof and of high insulating power. This compound to retain its elasticity at zero F. and not to drip at 160 degrees F.

This wire is not as burnable as the old "Weather-proof," nor as subject to softening under heat, but still is able to repel the ordinary amount of moisture found indoors. It would not usually be used for outside work.

43. **Slow-burning.**

a. The insulation shall be the same as the "Slow-burning Weather-proof," except that the outer braiding shall be impregnated with a fire-proofing compound similar to that required for the interior layers, and with the outer surface finished smooth and hard.

43. **Slow-burning.** — *Continued.*

This "slow-burning" wire shall only be used with special permission of the Inspection Department having jurisdiction.

This is practically the old "Underwriters" insulation. It is specially useful in hot, dry places where ordinary insulations would perish, also where wires are bunched, as on the back of a large switchboard or in a wire tower, so that the accumulation of rubber or weather-proof 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 damaged by moisture.

44. **Weather-proof** —

a. The insulating covering shall consist of at least three braids thoroughly impregnated with a dense moisture repellent, which will not drip at a temperature lower than 160 degrees F. The thickness of insulation shall be not less than that of "Slow-burning Weather-proof." The outer surface shall be thoroughly slicked down.

This wire is for outdoor use where moisture is certain and where fire-proof qualities are not necessary.

45. **Flexible Cord** —

a. Must be made of stranded copper conductors, each strand to be not larger than No. 26 or smaller than No. 30 B. & S. gauge, 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.

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

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

1st. A tight, close wind of fine cotton.
2d. The insulation proper, which shall be either water-proof or slow-burning.
3d. 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. Water-proof insulation must be solid, at least 1/32 of an inch thick, and must show an insulation resistance of 50 megohms per mile throughout two weeks' immersion in water at 70 degrees F., and stand the tests prescribed for low-tension wires as far as they apply.

e. Slow-burning insulation must be at least 1/32 of an inch in thickness and composed of substantial, elastic slow-burning

45. **Flexible cord for pendant lamps.**—*Continued.*

materials which will suffer no damage at a temperature of 250 degrees Fahrenheit.

Water-proof insulation may be used anywhere. Slow-burning insulation is only permissible in permanently dry places.

f. 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 flame-proof 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, etc.

g. Flexible cord for portable use must have water-proof insulation as required in section *d* for pendant cord, and in addition be provided with a reinforcing cover especially designed to withstand the abrasion it will be subject to in the uses to which it is to be put.

For portable heating apparatus.

h. Must be made up as follows:—

1st. A tight, close wind of fine cotton.

2d. A thin layer of rubber about 1/100-inch thick, or other cementing material.

3d. A layer of asbestos insulation at least 3/64-inch thick.

4th. A stout braid of cotton.

5th. An outer reinforcing cover especially designed to withstand abrasion.

This cord is in no sense water-proof, the thin layer of rubber being specified in order that it may serve merely as a seal to help hold in place the fine cotton and asbestos, and it should be so put on as to accomplish this.

46. **Fixture Wire**—

a. Must have a solid insulation, with a slow-burning, tough, outer covering, the whole to be at least 1/32 of an inch in thickness, and show an insulation resistance between conductors, and between either conductor and the ground, of at least one megohm per mile, after one week's submersion in water at 70 degrees Fahrenheit, and after three minutes' electrification, with 550 volts.

47. **Conduit Wire**—

Must comply with the following specifications:—

a. For metal conduits having a lining of insulating material, single wires must comply with Rule 41, and all duplex, twin and concentric conductors must comply with Rule 41, and must also have each conductor separately braided or taped and a substantial braid covering the whole.

b. For unlined metal conduits, conductors must conform to the specifications given for lined conduits, and in addition

47. **Conduit Wire.**— *Continued.*

have a second outer fibrous covering at least 1/32 of an inch in thickness, and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

The braid 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 be at least equal in thickness and of equal strength to resist penetration by nails, etc., as the armor or metal coverings of metal conduits (see No. 49 *b*).

b. The conductors in same, single wire or twin conductors, must have an insulating covering as required by No. 41, any filler used to secure a round exterior must be impregnated with a moisture repellent, and the whole bunch of conductors and fillers must have a separate exterior covering of insulating material at least 1/32 of an inch in thickness, conforming to the insulation standard given in No. 41 and covered with a substantial braid.

Very reliable insulation is specified, as such cables are liable to hard usage, and in any part of their length may be subject to moisture, while they may not be easily removable, so that a breakdown of insulation is likely to be expensive.

49. **Interior Conduits**—

(For wiring rules see Nos. 24 and 25.)

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

This makes it difficult for irresponsible makers to successfully get their stuff on the market, and renders it possible to place the responsibility for faulty pieces.

Metal Conduits with Lining of Insulating Material.

b. The metal covering or pipe must be equal in strength to 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 shown by the following table:—

SIZE. INCHES.	THICKNESS OF WALL.—INCHES.	SIZE. INCHES.	THICKNESS OF WALL.—INCHES.
1/2	.109	1 1/4	.140
5/8	.111	1 1/2	.145
3/4	.113	2	.154
1	.134		

An allowance of 2/100 of an inch for variation in manufacturing and loss of thickness by cleaning will be permitted.

49. **Metal Conduits with Lining of Insulating Material.**— *Continued.*

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 pipes.

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 1/32 of an inch in thickness, and 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 in and out of same long lengths of conductors.

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. 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.

Unlined Metal Conduits.

j. Plain iron or steel pipes of equal thickness and strengths specified for lined conduits in No. 49 *b* may be used as conduits, provided their interior surfaces are smooth and free from burs; pipe to be galvanized, or the interior surfaces coated or enameled, to prevent oxidization, with some substance which will not soften so as to become sticky and prevent 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. Must have not more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlet not being counted.

50. **Wooden Mouldings**—

(For wiring rules, see No. 24.)

a. Must have, both outside and inside, at least two coats of water-proof paint, or be impregnated with a moisture repellent.

50. **Wooden Mouldings.** — *Continued.*

The idea is to fill up the pores of the wood and prevent the possibility of its becoming saturated with water.

b. Must be made in two pieces, a backing and capping, so constructed as to thoroughly encase the wire, and provide a one-half inch tongue between the conductors, and a solid backing, which, under grooves, shall not be less than three-eighths of an inch in thickness, and must afford suitable protection from abrasion.

It is recommended that only hardwood moulding be used.

51. **Switches** —

(See Nos. 17 and 22.)

a. Must be mounted on non-combustible, non-absorptive, insulating bases, such as slate or porcelain.

b. Must have carrying capacity sufficient to prevent undue heating.

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

Indicating switches are much preferred for all work, as by showing at once whether the current is on or off they tend to save mistakes and possible accidents. The fact that lights do not burn or that a motor does not run is not necessarily a sure sign that the current is off, but the indicating switch makes it possible to surely cut the current off before beginning repairs.

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

This is to prevent mistakes and the accidents likely to follow if switches are used under conditions for which they were not designed. The name of the maker renders it possible to place the responsibility for failures.

e. Must, for constant-potential systems, operate successfully at fifty per cent. overload in amperes, with twenty-five per cent. excess voltage under the most severe conditions they are liable to meet with 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 the switch could safely stand a moderate amount of overloading.

f. Must, for constant-potential systems, have a firm and secure contact; must make and break readily, and not stop when motion has once been imparted by the handle.

g. 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, upon inspection, whether the current be "on" or "off."

If the switch does not have the qualities required by *f* and *g*, there is great liability of the contacts coming to rest with a slight space between them, which will be bridged by the current forming an arc sufficient to heat the switch to redness. Loose contacts are everywhere a source of heat.

52. **Cut-outs and Circuit-Breakers** —

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

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

Dampness tends to cause excessive leaks over the wet surfaces of the cut-outs, perhaps finally resulting in a short circuiting and dangerous heating.

b. Cut-outs must be provided with covers, 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, under the most severe conditions they are liable to meet with in practice, on short circuits with fuses rated at 50% above, and with a voltage 25% above the current and voltage for which they are designed.

There is always the possibility of a larger fuse than the cut-out was designed for being put in; again, the voltage in most plants can, under some conditions, increase considerably above the normal. The need of some margin as a factor of safety to prevent the cut-outs being ruined in ordinary service is, therefore, evident.

The most severe conditions which a cut-out is likely to meet in practice is a dead short circuit and only one fuse blowing.

d. Circuit-breakers must operate successfully, under the most severe conditions they are liable to meet with in practice, on short circuits when set at 50% above the current, and with a voltage 25% above that for which they are designed.

For the same reason as in *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.

For the same reasons that similar requirements were made for switches. See fine print No. 51 *d.*

It is desirable also to mark cut-outs on completed systems with the size of fuse belonging in them. This will tend to obviate the danger of replacing a burned-out fuse by one too large to protect the wires.

53. **Fuses** —

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

a. Must have contact surfaces or tips of harder metal having perfect electrical connection 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. Must be stamped with about 80% of the maximum current they can carry indefinitely, thus allowing about 25% overload before fuse melts.

With naked open fuses, of ordinary shapes, and 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.

53. **Fuses.** — *Continued.*

Enclosed fuses where the fuse is often in contact with substances having good conductivity to heat, and often of considerable volume, require a much longer time to reach a maximum temperature on account of the surrounding material which heats up slowly.

This data is given to facilitate testing.

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

For reasons entirely similar to those given under No. 51 *d.*

54. **Cut-out Cabinets** —

a. Must be so constructed, and cut-outs so arranged, as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

A suitable box can be made of marble, slate, or wood, strongly put together, the door to close against a rabbet so as to be perfectly dust tight, and it should be hung on strong hinges and held closed by a strong hook or catch. If the box is wood the inside should be lined with sheets of asbestos board about one-sixteenth of an inch in thickness, neatly put on and firmly secured in place by shellac and tacks. The wires should enter through holes bushed with porcelain bushings; the bushings tightly fitting the holes in the box, and the wires tightly fitting the bushings (using tape to build up the wire, if necessary) so as to keep out the dust.

(For general suggestions and descriptions, see Figs. 27, 28, 30 and 31, pages 95-101.

55. **Sockets** —

(*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 shall be suitable for use on any voltage not exceeding 250 and with any size lamp up to 50 C. P. For lamps larger than 50 C. P. 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 50 c. p., 250 v., and with either the manufacturer's name or registered trade-mark. Special large 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 place. Brass shells must be at least 0.013 inch in thickness, and shells of any other material must be thick enough to give the same stiffness and strength as brass.

d. **Lining.** — The inside of the shells must be lined with insulating material, which shall absolutely prevent the shell

55. **Sockets.** — *Continued.*

from becoming a part of the circuit even though the wires inside the socket should start from their position under binding screws.

The material used for lining must be at least 1/32-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 the 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.

e. **Cap.** — Caps when of sheet brass must be at least 0.013 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 and threaded for ordinary 1/8-inch pipe. It must contain sufficient metal for a full, strong thread, and when not of the same piece as the cap, must be joined to it in a way 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 push it into place in cap without crowding. All parts of the cap upon which the knot is likely to bear must be smooth and well insulated.

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

Brass pieces containing screw threads must be at least 0.06-inch in thickness.

Binding Post Screws must not be smaller than No. 5 wire and about 40 threads per inch.

g. **Spacing.** — Points of opposite polarity must everywhere be kept not less than 3/64-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. 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 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 lamp and socket.

j. **Base.** — The inside parts of the socket, which are of insulating material, except the lining, 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 50 candle-power lamp

55. **Sockets.** — *Continued.*

hanging downwards in air at 70 degrees F. from the socket, and must be securely, but not necessarily rigidly, attached to the metal spindle it is designed to turn.

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

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

n. **Test.** — The socket when slowly turned "on and off," at the rate of about two or three times per minute, must "make and break" the circuit six thousand times before failing, when carrying a load of 1 ampere at 220 volts.

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

p. **Sockets of Insulating Materials.** — 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.

q. **Inlet Bushing.** — When the socket is not attached to fixtures the threaded inlet must be provided with a strong insulating bushing having a *smooth* hole of at least 15/64-inch diameter. The corners 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.

56. **Hanger-boards** —

a. Hanger-boards must be so constructed that all wires and current carrying devices thereon shall 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.

For the same reasons that similar requirements were made under 51 *f* and *g*.

It is desirable to cut off both poles to the lamp, so that there would be no danger in handling it if the circuit were grounded.

57. **Arc Lamps** —

(For installation rules, see No. 19.)

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

b. Must be carefully insulated from the circuit in all their exposed parts.

To prevent a leakage of current to any object which should happen to come in contact with the outside framing of the lamp.

57. **Arc Lamps.** — *Continued.*

c. Must, for constant-current systems, be provided with an *approved* hand switch, also 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.

The object of the hand switch is to entirely disconnect the lamp for the purpose of adjustment or trimming, and the automatic switch to maintain continuity of the circuit, should the carbons fail to properly feed.

58. **Spark Arresters** —

(See No. 19 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. They shall be so arranged that a deposit of moisture will not destroy the insulating effect, and shall have an insulating resistance of at least 250,000 ohms between the gas-pipe attachments, and be sufficiently strong to resist the strain they will be liable to be subjected to in being installed.

Where wires carrying currents to incandescent lights on gas fixtures are used, it is absolutely necessary to pay particular attention to the insulation between the wires and the ground. This can best be done by using what is called an insulating joint, at the top of the gas-pipe, insulating the fixture in the room from the main pipe. This joint is made by interposing what is, in effect, a piece of gas-pipe made of an insulating material like hard rubber or porcelain.

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

Because soft rubber soon hardens and cracks.

60. **Resistance Boxes and Equalizers** —

(For installation rules, see No. 4.)

a. Must be equipped with metal, or with other non-combustible frames.

The word "frame" in this section relates to the entire case and surroundings of the rheostat, and not alone to the upholding supports.

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

61. **Reactive Coils and Condensers—**

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

Reactive coils may get very hot under some conditions, so that they should be treated, in general, like rheostats, although the danger of extreme overheating is not as great.

b. Condensers must be treated like 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 like sources of heat.

Condensers, like transformers, are practically harmless until some fault occurs in them.

Then the trouble may be backed up by the full capacity of the wires until the protecting devices work.

62. **Transformers—**

(For installation rules, see Nos. 11, 13 and 33.)

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 already outlined.

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

1st. 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 F.

2d. 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. Must be mounted on non-combustible bases, and must be so constructed as not to maintain an arc after the discharge has passed, and must have no moving parts.

Whenever an arrester works, the dynamo current tends to follow the lightning discharge, as the discharge volatilizes a little of the metal and forms a bridge of metal vapor between the points, which quite readily conducts electricity. The arrester must be so designed as to break this arc, otherwise the dynamos may be injured and the service interrupted. It is also desirable, of course, that the arrester should not be burned out, for if it is it will not be ready to take a second discharge.

Moving parts are apt to become corroded and stuck, thus rendering the arrester inoperative if they are depended upon.

Class E.

MISCELLANEOUS.

64. **Signalling Systems.** — (Governing wiring for Telephone, Telegraph, District Messenger, and Call-Bell circuits, Fire and Burglar Alarms, and all similar systems.)

a. Outside wires should be run in underground ducts, or strung on poles, and as far as possible kept off of buildings, and must not be placed on the same cross-arm with electric light or power wires.

Insulated wire is not required.

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.

This is to give wiremen ample room to get at all the wires.

c. All aerial conductors and underground conductors which are directly connected to aerial wires must be provided with some approved protective device, which shall be located as near their point of entrance to the building as possible, and not less than six inches from curtains or other inflammable material.

d. If the protector is placed inside of building, wires, from outside support to binding posts of protector, shall comply with the following requirements: —

1st. Must be of copper, and not smaller than No. 16 B. & S. gauge.

2d. Must have an *approved* rubber insulating covering. (See No. 41.)

3d. Must have drip loops in each wire immediately outside the building.

4th. Must enter buildings through separate holes sloping upward from the outside; when practicable, holes to be bushed with non-absorptive, non-combustible insulating tubes extending through their entire length. Where tubing is not practicable, the wires shall be wrapped with two layers of insulating tape.

5th. Must be supported on porcelain insulators, so that they will not come in contact with anything other than their designed supports.

6th. A separation between wires of at least two and one-half inches must be maintained.

In case of crosses these wires may become a part of a high-voltage circuit, so that similar care to that given high-voltage circuits is needed in placing them. Reliable porcelain bushings at the entrance holes are desirable, and are only waived under adverse conditions because the state of the art in this type of wiring makes an absolute requirement inadvisable.

64. Signalling Systems. — *Continued.*

e. The ground wire of the protective device shall be run in accordance with the following requirements: —

1st. Shall be of copper, and not smaller than No. 16 B. & S.

2d. Must have an approved rubber insulating covering. (See No. 41.)

3d. Shall run in as straight a line as possible to a good permanent ground, to be made by connecting to water or gas pipe, preferably water pipe. If gas pipe is used, the connection, in all cases, must be made between the meter and service pipes. In the absence of other good ground, the ground shall be made by means of a metallic plate or bunch of wires buried in permanently moist earth.

4th. Shall be kept at least three inches from all other conductors and supported on porcelain insulators, so as not to come in contact with anything other than its designed supports.

The method of making a "ground," shown in Fig. 7, page 70, might conveniently be used where pipes are not available.

In attaching a ground wire to a pipe, it is often difficult to make a thoroughly reliable solder joint. It is better, therefore, where possible, to carefully solder the wire to a brass plug, which may then be firmly screwed into a pipe fitting.

Where such joints are made underground, they should be thoroughly protected against corrosion by wrapping with tape and then painting.

f. The protector to be approved must comply with the following requirements: —

1st. 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 holding the protector.

2d. 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 which will operate before a sneak current can damage the instrument the protector is guarding.

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.

3d. 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."

64. **Signalling Systems.** — *Continued.*

g. Wires beyond the protector, except where bunched, must be neatly arranged and securely fastened in place in any 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 circular loom conduit may be used for encasing wires where required as above.

h. Wires connected with outside circuits, where bunched together within any building, or inside wires where laid in conduits or ducts with electric light or power wires, must have fire-resisting coverings, or else must be enclosed in an air-tight tube or duct.

It is feared that if a burnable insulation were used, a chance spark might ignite it and cause a serious fire, for many insulations contain a large amount of very readily burnable matter.

64A. **Additional Rules for Factory Mutual Work** —

In this work, the following rules, which are additional to the "Code," must be carefully followed, as the more or less isolated location of the majority of factory properties makes it possible to introduce some very desirable requirements not universally feasible.

a. Foreign wires (*i. e.*, those not owned or controlled by the insured, such as any public light or power wires, public telephone, telegraph, city fire-alarm wires, etc.) of all kinds, not used by the insured, should be kept off of all buildings, and out of the yards of properties insured by these companies.

Foreign wires, such as telephone, telegraph, etc., with their generally long circuits and often careless line construction, are specially apt to come in contact with light and power wires. If they are attached to mill buildings or allowed to cross mill yards, there is always the danger that they will break, and, coming in contact with some private mill wire, send a dangerous current into the buildings, with probably a resulting fire. Foreign light and power wires are excluded for similar reasons. Moreover, such wires are apt to be in the way of fire streams and ladders.

Under this heading would also come trolley wire supports, which are not desirable on buildings, as they may tend to conduct lightning to the building and also may not always be thoroughly insulated from the live trolley wire.

b. All wires used by the insured should be systematically laid out through the yards. Special care should be taken to so locate them that they will not interfere with fire streams or ladders.

This matter is ordinarily given too little attention, with the result that an unsightly tangle of wires eventually results, inviting crosses which can conduct dangerous currents into the buildings, and often so located as to obstruct fire streams and hinder the putting up of ladders.

64A. Additional Rules for Factory Mutual Work. — *Continued.*

c. Private wires (*i. e.*, those owned and controlled by the insured, such as watch-clock, private telephone, call-bell, and similar wires) must be arranged about as follows:

1st. Where possible, run them so that they cannot fall or be fallen upon by any wire carrying a dangerous current or likely to come in contact with a wire carrying a dangerous current.

2d. Where crosses cannot be prevented, provide guard wires that will absolutely prevent contacts.

3d. Where crosses must occur, and guard wires cannot be arranged, provide protectors as required by No. 64 above.

It will generally be found possible in arranging private wires about the mill yards to so keep them by themselves that there will be no possibility of their coming in contact with the circuits carrying dangerous currents. Such avoidance of the possibility of danger is always preferable to the putting in of safeguards. Moreover, by doing this the cost of protectors is saved.

65. Electric Gas Lighting —

Where electric gas-lighting is to be used on the same fixture with the electric light:

a. No part of the gas-piping or fixture shall be in electric connection with the gas-lighting circuit.

b. The wires used with the fixtures must have a non-inflammable insulation, or, where concealed between the pipe and shell of the fixture, the insulation must be such as required for fixture wiring for the electric light.

c. The whole installation must test free from "grounds."

d. The two installations must test perfectly free from connection with each other.

The use of the two systems on the same fixture is not desirable, as the gas-lighting wires are not run with the care necessary for electric-lighting circuits, and are almost certain, sooner or later, to come in contact with the electric-lighting wires.

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.) of not less than the following:

Up to	5	amperes	4,000,000
"	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

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.

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.

[CLASS F.—**MARINE WORK.**—Rules 68 to 80.—As the Factory Mutuals do not enter this class of work, these rules are not printed here.]