WIRING DESIGN AND PROTECTION

CHAPTER E-200

USE AND IDENTIFICATION OF GROUNDED CONDUCTORS

E-200.01. Scope.

This Chapter provides requirements for the use and identification of a grounded conductor in interior wiring systems. (See definitions of "grounded conductor" and "grounding conductor" in Chapter E-100.)

E-200.02. General

All interior wiring systems shall have a grounded conductor which is continuously identified throughout the system except as follows:

Exception No. 1: A grounded conductor is not required in certain circuits or systems as provided in E-200.05, E-250.003, E-250.005, E-250.006, E-250.007, E-250.008, E-503.13, and E-517.06.

Exception No. 2: Continuous identification throughout a length of a conductor between terminals is not required for certain conductors under E-200.06(1) and (2).

E-200.03. Connection to Grounded System.

No interior wiring shall be electrically connected to a supply system unless the latter contains, for any grounded conductor of the interior system, a corresponding conductor which is grounded.

Note: Electrically connected implies connection capable of carrying current as distinguished from connection through electromagnetic induction.

E-200.04. Circuits derived from Auto-Transformers.

Branch circuits as described in Chapter E-210 shall not be supplied through

auto-transformers (transformers in which a part of the winding is common to both primary and secondary circuits) unless the system supplied has an identified grounded conductor which is solidly connected to a similar identified grounded conductor of the system supplying the auto-transformer.

E-200.05. Unidentified Circuits.

(1) Two-wire branch circuits and multi-wire AC circuits may be tapped from the ungrounded conductors of circuits having identified grounded neutrals. Switching devices in such circuits shall have a pole in each ungrounded conductor, except as provided for motor controllers in E-430.084 and for heating equipment in E-422.29.

(2) Polyphase circuits need not have one conductor grounded and indentified, except as required by E-250.005, but where one conductor is grounded it shall be identified.

(3) Other unidentified ungrounded systems or circuits may be used only by special permission.

E-200.06. Means of Identification of Grounded Conductors.

Identification for grounded conductors shall be as follows:

(1) Insulated conductors of No. 6 or smaller, except conductors of Type MI cable, shall have an outer identification of white or natural gray color as specified in E-310.02(6). The grounded conductors of Type MI cable shall be identified by distinctive marking at the terminals during the process of installation.

(2) Insulated conductors larger than No. 6 shall have an outer identification of white or natural gray color or shall be identified by distinctive white marking at terminals during process of installation.

(3) Where, on a 4-wire delta-connected secondary, the midpoint of one phase is grounded to supply lighting and similar loads, that phase conductor having the higher voltage to ground shall be indicated by painting or other

effective means at any point where a connection is to be made if the neutral conductor is present.

E-200.07. Identified Conductor in Grounded Circuits Only.

Conductors having white or natural gray covering shall not be used other than as conductors for which identification is required by E-200.02, except under the following conditions, and then only where they are, in other respects, suitable for use as ungrounded conductors in the circuit:

Exception No. 1: Identified conductors, rendered permanently unidentified by painting or other effective means at each outlet where the conductors are visible and accessible, may be used as unidentified conductors.

Note: The foregoing permits the use of two-wire cable having one black and one white conductor on two-wire circuits tapped from the outside legs of a three-wire system or any two conductors of a multi-wire system where the identified conductor of the two-wire cable is rendered permanently unidentified at terminals.

Exception No. 2: Cable containing an identified conductor may be used for single-pole, three-way or four-way switch loops where the connections are so made that the unidentified conductor is the return conductor from the switch to the outlet.

Note: This exception makes it unnecessary to paint the terminal of the identified conductor at the switch outlet.

Exception No. 3: A flexible cord, for connecting a portable appliance, having one conductor identified as required by E-400.13 may be used even though there is no grounded conductor in the circuit supplying the outlet to which it is connected.

E-200.08. Connections to Screw-Shells.

An identified conductor, where run to a screw-shell lampholder, shall be connected to the screw-shell.

E-200.09. Means of Identification of Terminals.

The identification of terminals to which a grounded conductor is to be connected shall be by means of a metallic plated coating substantially white in color, such as nickel or zinc, or the terminals may be of material substantially white in color. The other terminals shall be of a readily distinguishable different color.

E-200.10. Identification of Terminals.

(1) Device Terminals.

All devices provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification except as follows:

Exception No. 1: Marking may be omitted where the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.

Exception No. 2: Single-pole Devices. Devices to the terminals of which only one side of the line is connected need not have terminals marked for identification.

Exception No. 3: Panelboards and Devices. The terminals of lighting panelboards and of devices having a normal current rating of over 30 amperes need not be marked for identification, except as required in E-200.10(2) for polarized receptacles for attachment plugs and polarized attachment-plugs.

(2) Plugs and Receptacles.

Two-wire polarized receptacles for attachment plugs and polarized attachment plugs shall have the terminal intended for connection to the grounded conductor marked for identification.

Exception No. 1: Two-wire attachment plugs, unless of the polarity type, need not have their terminals marked for identification.

Exception No. 2: Three-wire Receptacles and Plugs. Three-wire attachment-plug receptacles and three-wire attachment plugs, one terminal of which may be used for the connection of a grounding conductor, shall have such terminal

indicated in a manner differing from that specified in E-200.09. The other terminals need not be marked for identification.

(3) Screw-Shells.

In the case of devices with screw-shells, the identified terminal shall be the one connected to the screw-shell. This does not apply to screw-shells which serve as fuseholders.

(4) Screw-Shell Devices with Leads.

In the case of screw-shell devices with attached leads, the conductor attached to the screw-shell shall have white or natural gray finish. The outer finish of the other conductor shall be of a solid color that will not be confused with the white or natural-gray finish which is to identify the grounded conductor.

(5) Fixed Appliances.

The terminals of fixed appliances need not be marked to indicate the proper connection to the grounded conductor unless a single-pole switch forms an integral part, then the terminal connected to the switch shall be the unidentified terminal.

(6) Portable Appliances.

The terminals of portable appliances need not be marked for identification.

CHAPTER E-210

BRANCH CIRCUITS

E-210.01. Scope.

The provisions of this Chapter shall apply to branch circuits supplying lighting or appliance loads or combinations of such loads. Where motors, or motor-operated appliances, are connected to any circuit supplying lighting or other appliance loads, the provisions of both this Chapter and Chapter E-430 shall apply. Chapter E-430 shall apply where branch circuit supplies only motor loads.

E-210.02. Specific Purpose Branch Circuit.

The provisions applying to branch circuits referred to in the following table are exceptions to the provisions of this Chapter or are supplementary thereto, and shall apply to branch circuits supplying the loads referred to therein:

Busways	Rule E-364.08
Cranes and Hoists	Rule E-610.42
Elevators, Dumbwaiters and Escalators	Rule E-620.61
Infra-red Industrial Heating Equipment	Rule E-422.11
Inductive and Dielectric Heat Generating Equipment	Chapter E-665
Instruments	Rule E-384.22
Motion Picture Studios and Similar Locations	Chapter E-530
Motors and Motor Controllers	Chapter E-430
Organs	Rule E-650.06
Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits	Chapter E-725
Signs and Outline Lighting	Rule E-600.06
Sound Recording and Reproduction	Rule E-640.06
Space Heating; Panel and Embedded Types	Chapter E-422
Systems over 600 Volts	Chapter E-710
Systems under 50 Volts	Chapter E-720
Theatres and Assembly Halls	Rules E-520.41, E-520.52 and E-520.62
Welders	Chapter E-630
X-ray Equipment	Rule E-660.03

E-210.03. Classifications.

Branch circuits recognized by this Chapter shall be classified in accordance

with the maximum permitted rating or setting of the overcurrent device, and the classification for other than individual branch circuits shall be 15, 20, 30 and 50 amperes. When conductors of higher capacity are used for any reason, the rating or setting of the specified overcurrent device shall determine the circuit classification.

A. GENERAL PROVISIONS

E-210.04. Multi-Wire Branch Circuits.

Branch circuits recognized by this Chapter may be installed as multi-wire circuits. A multi-wire branch circuit as referred to herein is a circuit consisting of two or more ungrounded conductors having a potential difference between them, and an identified grounded conductor having equal potential difference between it and each ungrounded conductor of the circuit and which is connected to the neutral conductor of the system.

E-210.05. Color Code.

(1) Where installed in raceways, as open work, or as concealed knob-and-tube work, the conductors of multi-wire branch circuits and two-wire branch circuits connected to the same system shall conform to the following color code. Three-wire circuits - one black, one white, one red; four-wire circuits - one black, one white, one red, one blue; five-wire circuits - one black, one white, one red, one blue, one yellow. Where more than one multi-wire branch circuit is carried through a single raceway the ungrounded conductors of the additional circuit may be of colors other than those specified. All circuit conductors of the same color shall be connected to the same ungrounded feeder conductor throughout the installation.

(2) Any conductor intended solely for equipment grounding purposes shall be identified by a green color unless it be bare. Except for public highway traffic, control, communications, metering, railway, and railroad signal installations, conductors having a green covering shall not be used for other than grounding purposes.

Note: See E-200.07 for use of white or natural gray for grounded or neutral conductors.

E-210.06. Voltage.

(1) The voltage to ground on branch circuits supplying lampholders, fixtures, or standard receptacles of 15-ampere or less rating shall not exceed 150 volts, except as follows:

Exception No. 1. In industrial establishments the voltage of branch circuits which supply only lighting fixtures that are equipped with mogul-base screw-shell lampholders or with lampholders of other types approved for the application, mounted not less than eight feet from the floor, which do not have switch control as an integral part of the fixture shall not exceed 300 volts to ground;

Exception No. 2. In industrial establishments, office buildings, schools, stores, and public and commercial areas of other buildings, such as hotels or transportation terminals, the voltage of branch circuits which supply only the ballasts for electric discharge lamps in permanently installed fixtures mounted not less than eight feet from the floor, which do not have manual switch control as an integral part of the fixture shall not exceed 300 volts to ground;

Exception No. 3. For infra-red industrial heating appliances as described in E-422.11;

Exception No. 4. In railway properties as described in E-195.18.

(2) Voltage Between Conductors - Dwellings.

In dwelling occupancies, the voltage between conductors supplying lampholders of the screw-shell type, receptacles, or appliances, shall not exceed 150 volts, except as follows:

Exception: The voltage between conductors may exceed 150 volts when supplying only:

(a) Permanently connected appliances,

(b) Portable appliances of more than 1,330 watts,

(c) Portable motor-operated appliances of $\frac{1}{4}$ horsepower or greater rating.

E-210.07. Grounding Receptacles.

Where a grounding receptacle is installed as specified in E-210.22(2) and

E-250.059, to provide grounding facilities required in E-250.045, the branch circuit or branch circuit raceway shall include or provide a grounding conductor to which the grounding contacts of the grounding receptacle shall be connected. The metal armor of armored cable or a metallic raceway is acceptable as a grounding conductor.

E-210.08. Heavy-Duty Lampholders.

Heavy-duty lampholders referred to in this Chapter shall include lampholders rated at not less than 750 watts.

Exception: Admedium lampholders rated at 660 watts shall be considered to be heavy duty type.

B. SPECIFIC REQUIREMENTS

E-210.19. Conductors.

Circuit conductors shall conform to the following:

(1) Carrying Capacity.

Shall have a carrying capacity of not less than the rating of the branch circuit and not less than the maximum load to be served.

(2) Minimum Size.

Shall not be smaller than No. 8 for ranges of 8-3/4 kw or more rating, nor smaller than No. 14 for other loads.

(3) Exceptions:

Exception No. 1. Range Loads. See Note 5 of Table E-220.05. Where the maximum demand of a range of 8-3/4 kw or more rating is computed according to Column A of Table E-220.05, the neutral conductor of a three-wire branch circuit supplying a household electric range, a wall-mounted oven or a counter-mounted cooking unit may be smaller than the ungrounded conductors but shall have a carrying capacity at least 70 per cent of the current-carrying capacity of the ungrounded conductors and shall not be smaller than No. 10.

Note: Cable assemblies with the neutral conductor smaller than the ungrounded conductor shall be so marked.

Exception No. 2. Tap Conductors. Tap conductors may be of less capacity than the branch circuit rating provided no tap conductor is of less capacity than the load to be served and provided the rating is not less than 20 amperes for 50 ampere circuits or 15 amperes for circuits rated less than 50 amperes and only when these tap conductors supply either:

(1) Individual lampholders or fixtures with taps extending not longer than 18 inches beyond any portion of the lampholder or fixture, except as required in E-410.65(2)(b); or,

(2) Individual outlets with taps not over 18 inches long; or,

(3) Infra-red lamp industrial heating appliances.

(4) Tap conductors supplying electric ranges, wall-mounted electric ovens and counter-mounted electric cooking units from 50 ampere branch circuits shall be no longer than necessary for servicing.

Exception No. 3. Fixture Wires and Cords. Fixture wires and cords may be of smaller size, but not less than the size specified in Exception No. 3 of E-240.05.

See Tables E-400.09(2) and E-402.04.

Exception No. 4. Outlet Devices. Outlet devices may have less carrying capacity than the branch circuit rating, but not less than the types and ratings specified in E-210.21(1) - (3).

E-210.20. Overcurrent Protection.

The rating or setting of overcurrent devices shall conform to the following:

(1) Rating

Shall not be in excess of the carrying capacity of the circuit conductor.

Exception: Tap Conductors and Fixture Wires. Tap conductors, fixture wires and cords as permitted in E-210.19(3) may be considered as protected by the circuit

overcurrent device.

(2) Single Appliance.

Shall not exceed 150 per cent of the rating of the appliance, where the circuit supplies only a single appliance of 10-ampere or more rating.

E-210.21. Outlet Devices.

Outlet devices shall have a rating not less than the load to be served and shall conform to the following:

(1) Lampholders.

Lampholders when connected to circuits having a rating of over 20 amperes shall be of the heavy duty type.

(2) Receptacles.

(a) When connected to circuits having two or more outlets, receptacles shall conform to the following:

15-amp. circuits	Not over 15-amp. rating
20-amp. circuits	15 or 20-amp. rating
30-amp. circuits	30-amp. rating
50-amp. circuits	50-amp. rating

(b) Receptacles connected to circuits having different voltages, frequencies or types of current (AC or DC) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable.

(c) Grounding receptacles rated at 15 or 20 amperes and installed in circuits of less than 150 volts between conductors shall be approved for use only on potentials less than 150 volts. Grounding receptacles rated at 15 amperes and installed in circuits of 151 to 300 volts between conductors shall be approved for use only on potentials not less than 151 volts.

(d) Receptacles rated at 15 amperes connected to 15 or 20 ampere branch circuits serving two or more outlets shall not supply a total load in excess of 12 amperes for portable appliances.

(3) Capacity of range receptacles may be based on single range loads as computed from Table E-220.05.

E-210.22. Receptacle Outlets Required.

Receptacle outlets shall be installed as follows:

(1) General.

Where portable cords are used, except where the attachment of cords by other means is specifically permitted.

Note: A cord connector that is supported by a permanently connected cord pendant is considered a receptacle outlet.

(2) Dwelling Type Occupancies.

(a) In every kitchen, dining room, breakfast room, living room, parlor, library, den, sun room, recreation room and bedroom, receptacle outlets shall be installed so that no point along the floor line in any usable wall space is more than six feet, measured horizontally, from an outlet in that space including any usable wall space two feet wide or greater and the wall space occupied by sliding panels in exterior walls. The receptacle outlets shall, insofar as practicable, be spaced equal distances apart. Receptacle outlets in floor shall not be counted as part of the required number of receptacle outlets unless located close to the wall.

(b) Only grounding type outlets shall be installed in kitchens, laundry rooms, open porches, breezeways, basements, cellars, work shops, garages, on the exterior surfaces of outside walls or in like locations where the outlet may supply equipment used by persons standing on the ground or on grounded conductive materials. These outlets shall be installed in accordance with E-210.07.

E-210.23. Maximum Load.

The maximum load shall conform to the following:

(1) Motor-Operated Appliances.

The total load shall not exceed 80 per cent of the branch circuit rating

if motor-operated appliances are supplied. Where circuit supplies only motor-operated appliance loads, Chapter E-430 is to apply.

(2) Other Loads.

The total load shall not exceed the branch circuit rating, and shall not exceed 80 per cent of the rating where in normal operation the load will continue for long periods such as store lighting and similar loads. In computing the load of lighting units which employ ballasts, transformers or auto-transformers, the load shall be based on the total of the ampere rating of such units and not on the wattage of the lamps.

Exception: Range Loads. See Note 5 of Table E-220.05.

E-210.24. Permissible Loads.

Individual branch circuits may supply any loads. Branch circuits having two or more outlets may supply only loads as follows:

(1) 15- and 20-Ampere Branch Circuits.

Lighting units and/or appliances. The rating of any one portable appliance shall not exceed 80 per cent of the branch circuit rating. The total rating of fixed appliances shall not exceed 50 per cent of the branch circuit rating when lighting units or portable appliances are also supplied.

(2) 30-Ampere Branch Circuits.

Fixed lighting units with heavy duty lampholders in other than dwelling occupancies; or appliances in any occupancy. The rating of any one portable appliance shall not exceed 24 amperes.

(3) 50-Ampere Branch Circuits.

Fixed lighting units with heavy duty lampholders in other than dwelling occupancies; or fixed cooking appliances; or fixed range and water heater; or infra-red lamp industrial heating appliances.

Note: The term "fixed" as used in this section recognizes cord connections where otherwise permitted.

E-210.25. Table of Requirements.

The requirements for circuits having two or more outlets (other than the receptacle circuits of E-220.03(2)) as specifically provided for above are summarized in Table E-210.25.

Table E-210.25

Branch Circuit Requirements

(Type R, RW, RU, RUW, RH-RW, SA, T, TW, RH, RUH, RHW, RHH and THW conductors in raceway or cable)

CIRCUIT RATING	15 Amp.	20 Amp.	30 Amp.	50 Amp.
CONDUCTORS: (Min. Size)				
Circuit Wires	14	12	10	6
Taps	14	14	14	12
Fixture Wires and Cords	Refer to Rule E-240.05, Exception No. 3			
OVERCURRENT PROTECTION	15 Amp.	20 Amp.	30 Amp.	50 Amp.
OUTLET DEVICES:				
Lampholders Permitted	Any Type	Any Type	Heavy Duty	Heavy Duty
Receptacle Rating	15 Max. Amp.	15 or 20 Amp.	30 Amp.	50 Amp.
MAXIMUM LOAD	15 Amp.	20 Amp.	30 Amp.	50 Amp.
PERMISSIBLE LOAD	Refer to Rule E-210.24(1)	Refer to Rule E-210.24(1)	Refer to Rule E-210.24(2)	Refer to Rule E-210.24(3)

CHAPTER E-215 - FEEDERS

E-215.01. Scope.

This Chapter deals with the sizes of conductors in the feeders needed to supply power to the loads as calculated under Chapter E-220.

E-215.02. Conductor Size.

(1) Feeder conductors shall have a current rating not smaller than the feeder load as determined by E-220.04. A 2-wire feeder supplying two or more 2-wire branch circuits, or a 3-wire feeder supplying more than two 2-wire branch circuits, or two or more 3-wire branch circuits, shall be not smaller than No. 10. Where a feeder carries the total current supplied by the service-entrance conductors, such feeder, for services of No. 8 and smaller, shall be of the same size as the service-entrance conductors.

(2) Where at any time it is found that feeder conductors are, or will be, overloaded, the feeder conductors shall be increased in capacity to accommodate the actual load served.

Note: See Examples Nos. 1 to 7 of Chapter E-900.

E-215.03. Voltage Drop.

The size of the feeder conductors should be such that voltage drop up to the final distribution point for the load as computed by E-220.04 will not be more than 3 per cent for power or heating loads, and not more than 1 per cent for lighting loads or combined lighting, heating and power loads.

E-215.04. Overcurrent Protection.

Feeders shall be protected against overcurrent in accordance with the provisions of Chapter E-240.

E-215.05. Common Neutral Feeder.

A common neutral feeder may be employed for two or three sets of 3-wire feeders, or two sets of 4-wire or 5-wire feeders. When in metal enclosures, all conductors of feeder circuits employing a common neutral feeder shall be

contained within the same enclosure as provided in E-300.20.

E-215.06. Diagram of Feeders.

If required by the administrative authority, a diagram showing feeder details shall be supplied previous to installation. This diagram should show: Area in square feet; load (before applying demand-factors); demand-factors selected; computed load (after applying demand-factors); and the size of conductors.

CHAPTER E-220

BRANCH CIRCUIT AND FEEDER CALCULATIONS

E-220.01. Scope.

This Article provides the basis for calculating the expected branch circuit and feeder loads and for determining the number of branch circuits required.

E-220.02. Calculation of Branch Circuit Loads.

(1) The load for branch circuits shall be computed in accordance with the provisions of this Rule.

(2) Where in normal operation the maximum load of a branch circuit will continue for long periods of time, such as store lighting and similar loads, the minimum unit loads specified in this Rule shall be increased by 25 per cent.

(3) General Lighting Load.

(a) In Listed Occupancies. In the occupancies listed in Table E-220.02 (3)(a)2, a load of not less than the unit load specified shall be included for each square foot of floor area.

1. In determining the load on the "watts per square foot" basis, the floor area shall be computed from the outside dimensions of the building, apartment or area involved, and the number of floors; not including open porches, garages in connection with dwelling occupancies, nor unfinished spaces and unused spaces in dwellings unless adaptable for future use.

Note 1. The unit values herein are based on minumum load conditions and 100 per cent power factor, and may not provide sufficient capacity for the installation contemplated.

Note 2. In view of the trend toward higher intensity lighting systems and increased loads due to more general use of fixed and portable appliances, each installation should be considered as to the load likely to be imposed and the capacity increased to insure safe operation.

Note 3. Where electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

Table E-220.02(3)(a)2.

General Lighting Loads by Occupancies

Type of Occupancy	Unit Load per Sq. Ft. (Watts)
Armories and Auditoriums	1
Banks	2
Barber Shops and Beauty Parlors	3
Churches	1
Clubs	2
Court Rooms	2
*Dwellings (Other Than Hotels)	3
Garages - Commercial (storage)	$\frac{1}{2}$
Hospitals	2
*Hotels, including apartment houses without provisions for cooking by tenants	2
Industrial Commercial (Loft) Buildings	2
Lodge Rooms	$1\frac{1}{2}$
Office Buildings	5
Restaurants	2
Schools	3
Stores	3
Warehouses Storage	$\frac{1}{4}$
In any of the above occupancies except single-family dwellings and individual apartments of multi-family dwellings:	
Assembly Halls and Auditoriums	1
Halls, Corridors, Closets	$\frac{1}{2}$
Storage Spaces	$\frac{1}{4}$

*All receptacle outlets of 15-ampere or less rating in single-family and multi-family dwellings and in guest rooms of hotels (except those connected to the receptacle circuits specified in E-220.03(2)) may be considered as outlets for

general illumination, and no additional load need be included for such outlets. The provisions of E-220.02(4) shall apply to all other receptacle outlets.

(b) In Other Occupancies. In other occupancies, a load of not less than the unit load specified in E-220.02(4) shall be included for each outlet.

(4) Other Loads. For lighting other than general illumination and for appliances other than motors, a load of not less than the unit load specified below shall be included for each outlet.

*Outlets supplying specific appliances and other loads... . . . . .

. . . . . Amp. rating of appliance

Outlets supplying heavy-duty lampholders . . . . . 5 amperes

‡Other outlets . . . . . $1\frac{1}{2}$ amperes

*For motors, see E-430.022 and E-430.024.

‡This provision not applicable to receptacle outlets connected to the circuits specified in E-220.03(2) nor to receptacle outlets provided for the connection of fixed lighting units to facilitate servicing and replacement.

(5) Exceptions. The minimum load for outlets specified in E-220.02(4) shall be modified as follows:

Exception No. 1. Ranges. For household electric ranges, the branch circuit load may be computed in accordance with Table E-220.05.

Exception No. 2. Show-Window Lighting. For show-window lighting a load of not less than 200 watts for each linear foot of show-window, measured horizontally along its base, may be allowed in lieu of the specified load per outlet.

Exception No. 3. Multi-Outlet Assemblies. Where fixed multi-outlet assemblies are employed, each five feet or fraction thereof of each separate and continuous length shall be considered as one outlet of not less than $1\frac{1}{2}$ ampere capacity; except in locations where a number of appliances are likely to be used simultaneously, when each one foot or fraction thereof shall be considered as an outlet of not less than $1\frac{1}{2}$ amperes. The requirements of this Rule are not applicable to dwellings or the guest rooms of hotels.

Exception No. 4 Telephone Exchanges. Shall be waived for manual switchboards and switching frames in telephone exchanges.

(6) Existing Installations. Additions to existing installations shall conform to the following:

(a) Dwelling Occupancies. New circuits or extensions to existing circuits may be determined in accordance with E-220.02(3) or (4); except that portions of existing structures not previously wired, or additions to the building structure, either of which exceeds 500 square feet in area, shall be determined in accordance with E-220.02(3).

(b) Other Than Dwelling Occupancies. When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of E-220.02(3) or (4) shall apply.

E-220.03. Branch Circuits Required.

Branch circuits shall be installed as follows:

(1) Lighting and Appliance Circuits.

(a) For lighting, and for appliances, including motor-operated appliances, not specifically provided for in E-220.03(2), branch circuits shall be provided for a computed load not less than that determined by E-220.02.

(b) The number of circuits shall be not less than that determined from the total computed load and the capacity of circuits to be used. In every case the number shall be sufficient for the actual load to be served, and the branch circuit loads shall not exceed the maximum loads specified in E-210.23.

(c) Where the load is computed on a "watts per square foot" basis, the total load, in so far as practical, shall be evenly proportioned among the branch circuits according to their capacity.

Note 1. When lighting units to be installed operate at other than 100 per cent power factor, see E-210.23(2) for maximum ampere load permitted on branch circuits.

Note 2. For general illumination in dwelling occupancies, it is recommended that not less than one branch circuit be installed for each 500 square feet of floor area in addition to the receptacle circuits called for in E-220.03(2).

See examples No. 1, 1a, 1b, 1c, and 4, Chapter E-900.

(2) Receptacle Circuits, Dwelling Occupancies.

For the small appliance load in kitchen, laundry, pantry, dining-room and breakfast-room of dwelling occupancies, two or more 20 ampere branch circuits in addition to the branch circuits specified in E-220.03(1) shall be provided for all receptacle outlets (other than outlets for clocks) in these rooms, and such circuits shall have no other outlets.

Note. A three wire 115/230 volt branch circuit is the equivalent of two 115 volt receptacle branch circuits.

(3) Other Circuits.

For specific loads not otherwise provided for in E-220.03(1) or (2), branch circuits shall be as required by other rules of the Code.

E-220.04. Calculation of Feeder Loads.

The computed load of a feeder shall be not less than the sum of all branch circuit loads supplied by the feeder, as determined by E-220.02, subject to the following provisions:

(1) General Lighting. The demand factors listed in E-220.04(2) may be applied to that portion of the total branch circuit load computed for general illumination. These demand factors shall not be applied in determining the number of branch circuits for general illumination supplied by the feeders.

Note 1. See E-220.04(8) and (9).

Note 2. The demand factors herein are based on minimum load conditions and 100 per cent power factor, and in specific instances may not provide sufficient capacity for the installation contemplated. In view of the trend toward higher intensity lighting systems and increased loads due to more general use of fixed and portable appliances, each installation should be considered as to the load

likely to be imposed and the capacity increased to insure safe operation. Where electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

Table E-220.04(2)

Calculation of Feeder Loads by Occupancies

Type of Occupancy	Portion of Lighting Load to which Demand Factor Applies (wattage)	Feeder Demand Factor
Dwellings - other than Hotels	First 3000 or less at	100%
	Next 3001 to 120,000 at	35%
	Remainder over 120,000 at	25%
*Hospitals	First 50,000 or less at	40%
	Remainder over 50,000 at	20%
*Hotels - including Apartment Houses without provision for cooking by tenants	First 20,000 or less at	50%
	Next 20,001 to 100,000 at	40%
	Remainder over 100,000 at	30%
Warehouses (Storage)	First 12,500 or less at	100%
	Remainder over 12,500 at	50%
All Others	Total Wattage	100%

*The demand factors of this Table shall not apply to the computed load of sub-feeders to areas in hospitals and hotels where entire lighting is likely to be used at one time; as in operating rooms, ballrooms, or dining rooms.

(3) Show-Window Lighting. For show-window lighting, a load of not less than 200 watts shall be included for each linear foot of show-window measured horizontally along its base.

(4) Motors. For motors, a load computed according to the provisions of E-430.006, E-430.022, E-430.024, E-430.025 and E-430.026.

(5) Neutral Feeder Load. The neutral feeder load shall be the maximum unbalance of the load determined by E-220.04. The maximum unbalanced load shall be the maximum connected load between the neutral and any one ungrounded conductor; except that the load thus obtained shall be multiplied by 140 per cent for 5-wire, 2-phase systems. For a feeder supplying household electric ranges, wall-mounted ovens and counter-mounted cooking units, the maximum unbalanced load shall be considered as 70 per cent of the load on the ungrounded conductors, as determined

in accordance with E-220.05. For 3-wire DC or single-phase AC, 4-wire 3-phase and 5-wire 2-phase systems, a further demand factor of 70 per cent may be applied to that portion of the unbalanced load in excess of 200 amperes. There shall be no reduction of the neutral capacity for that portion of the load which consists of electric discharge lighting.

See Examples 1, 1a, 1b, 1c, 2, 3, 4 and 5, Chapter E-900.

(6) Fixed Electrical Space Heating. The computed load of a feeder supplying fixed electrical space heating equipment shall be the total connected load on all branch circuits.

Exception No. 1. Where reduced loading of the conductors results from units operating on duty-cycle, intermittently, or from all units not operating at one time, the administrative authority may grant permission for feeder conductors to be of a capacity less than 100 per cent, provided the conductors are of sufficient capacity for the load so determined.

Exception No. 2. E-220.04(6) does not apply when feeder capacity is calculated in accordance with optional method in E-220.07 for one-family residences.

(7) Non-coincident Load. In adding the branch circuit loads to determine the feeder load, the smaller of two dissimilar loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously .

(8) Small Appliances. The computed branch circuit load for receptacle outlets in other than dwelling occupancies, for which the allowance is not more than 1½ amperes per outlet, may be included with the general lighting load and subject to the demand factors in E-220.04(1).

Dwelling Occupancies

Note: The requirements in following E-220.04(9) - (12) apply to dwelling type occupancies and are supplemental to E-220.04(1) - (8).

(9) Small Appliances - Dwelling Occupancies. In single-family dwellings, in individual apartments of multi-family dwellings having provisions for cooking by tenants, and in each hotel suite having a serving pantry, a feeder load of not less

than 3,000 watts shall be included for small appliances (portable appliances supplied from receptacles of 15 or 20 ampere rating) in pantry and breakfast-room, dining room, kitchen and laundry. Where the load is subdivided through two or more feeders, the computed load for each shall include not less than 3,000 watts for small appliances. These loads may be included with the general lighting load and subject to the demand factors in E-220.04(1).

(10) Electric Ranges. The feeder load for household electric ranges and other cooking appliances, individually rated more than 1-3/4 kw, may be calculated in accordance with E-220.05.

Note: In order to provide for possible future installation of ranges of higher ratings, it is recommended that where ranges of less than 8-3/4 kw ratings or wall-mounted ovens and counter-mounted cooking units are to be installed, the feeder capacity be not less than the maximum demand value specified in Column A of Table E-220.05.

(a) Where a number of single-phase ranges are supplied by a 3-phase, 4-wire feeder, the current shall be computed on the basis of the demand of twice the maximum number of ranges connected between any two phase wires.

Note: See Example 7, Chapter E-900.

(11) Fixed Appliances (Other than Ranges, Air conditioning Equipment or Space Heating Equipment). Where four or more fixed appliances other than electric ranges, air conditioning equipment or space heating equipment are connected to the same feeder in a single or multi-family dwelling, a demand factor of 75 per cent may be applied to the fixed appliance load.

(12) Space Heating and Air Cooling. In adding branch circuit loads for space heating and air cooling in dwelling occupancies, the smaller of the two loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously.

Table E-220.05

Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units and Other Household Cooking Appliances Over 1-3/4 kw Rating

Column A to be used in all cases except as otherwise permitted in Note 4 below.

NUMBER OF APPLIANCES	Maximum Demand (See Notes)	Demand Factors (See Note 4)	
	COLUMN A (Not over 12 kw Rating)	COLUMN B (Less than 3½ kw Rating)	COLUMN C (3½ kw to 8-3/4 kw Rating)
1	8 kw	80%	80%
2	11 kw	75%	65%
3	14 kw	70%	55%
4	17 kw	66%	50%
5	20 kw	62%	45%
6	21 kw	59%	43%
7	22 kw	56%	40%
8	23 kw	53%	36%
9	24 kw	51%	35%
10	25 kw	49%	34%
11	26 kw	47%	32%
12	27 kw	45%	32%
13	28 kw	43%	32%
14	29 kw	41%	32%
15	30 kw	40%	32%
16	31 kw	39%	28%
17	32 kw	38%	28%
18	33 kw	37%	28%
19	34 kw	36%	28%
20	35 kw	35%	28%
21	36 kw	34%	26%
22	37 kw	33%	26%
23	38 kw	32%	26%
24	39 kw	31%	26%
25	40 kw	30%	26%
26-30	(15 kw plus 1 kw)	30%	24%
31-40	(for each range)	30%	22%
41-50	(25 kw plus 3/4)	30%	20%
51-60	(kw for each)	30%	18%
61 & over	(range)	30%	16%

Note 1.. Over 12 kw to 21 kw ranges all of same kw rating. For ranges, individually rated more than 12 kw but not more than 21 kw, the maximum demand in Column A shall be increased 5 per cent for each additional kw of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kw.

Note 2. Over 12 kw to 21 kw ranges of unequal ratings. For ranges individually rated more than 12 kw and of different ratings but none exceeding 21 kw an average value of rating shall be calculated by adding together the ratings of all ranges to obtain the total connected load (using 12 kw for any range rated less than 12 kw) and dividing by the total number of ranges; and then the maximum demand in Column A shall be increased 5 per cent for each kw or major fraction therof by which this average value exceeds 12 kw.

Note 3. Generally, the demand for commercial ranges should be based on the maximum nameplate rating.

Note 4. Over 1-3/4 kw to 8-3/4 kw. In lieu of the method provided in Column A, loads rated more than 1-3/4 kw but not more than 8-3/4 kw may be considered as the sum of the nameplate ratings of all the loads, multiplied by the demand factors specified in Columns B or C for the given number of loads.

Note 5. Branch Circuit Load. Branch circuit load for one range may be computed in accordance with Table E-220.05. The branch circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance.

Table E-220.06

Demand Factors for Household Electric Clothes Dryers

Number of Dryers	Demand Factor (per cent)
1	100
2	100
3	100
4	100
5	80
6	70
7	65
8	60
9	55
10	50
11-13	45
14-19	40
20-24	35
25-29	32.5
30-34	30
35-39	27.5
40 up	25

Note: The demand factor permitted in E-220.04(11) will not apply when this table is used

E-220.07. Optional Calculation for One-Family Residence.

For a one-family residence served by a 115/230 volt, 3-wire, 100 amp. or larger service where the total load is supplied by one feeder or one set of service entrance conductors, the following percentages may be used in lieu of the method of determining feeder (and service) loads detailed in E-220.04.

Table E-220.07

(1) Optional Calculation for One-Family Residence

LOAD (in kw or kva)	Per Cent of Load
Air conditioning and cooling including heat pump compressors (see E-220.04(12)	100%
Central electrical space heating (see E-220.04(12)	100%

Less than four separately controlled electrical space heating units (see E-220.04(12)	100%
First 10 kw of all other load	100%
Remainder of other load	40%

(2) All other load shall include 1500 watts for each 20 ampere appliance outlet circuit (E-220.03(2));lighting and portable appliances at 3 watts per square foot; all fixed appliances, (including four or more separately controlled space heating units (see E-220.04(12)),ranges, wall-mounted ovens and counter-mounted cooking units) at nameplate rated load (kva for motors and other low power-factor loads).

See Examples 1(b) and 1(c) of Chapter E-900.

CHAPTER E-230 - SERVICES

A. General Requirements

E-230.001. Scope.

The provisions of this Chapter shall apply to the conductors and equipment for control and protection of services - circuits that conduct electric power from the supply system or plant to the premises to be served.

Note: For over 600 volts see E-230.100

E-230.002. Number of Services to a Building.

In general, a building shall be supplied through only one set of service conductors, except as follows:

Exception No. 1. Fire Pumps. Where a separate service is required for fire pumps.

Exception No. 2. Emergency Lighting. Where a separate service is required for emergency lighting purposes.

Exception No. 3. Multiple-Occupancy Buildings.

(1) By special permission, in multiple-occupancy buildings where there is no available space for service equipment accessible to all the occupants.

(2) Buildings of multiple occupancy may have two or more separate sets of service-entrance conductors which are tapped from one service drop, or two or more sub-sets of service-entrance conductors may be tapped from a single set of main service conductors. See E-230.070(2) and E-230.090(1)(d).

Exception No. 4. Capacity Requirements. Where capacity requirements make multiple services desirable.

Exception No. 5. Buildings of Large area. By special permission, where more than one service drop is necessary due to the area over which a single building extends.

Exception No. 6. Different Characteristics or Classes of Use. Where additional services are required for different voltages, frequency, or phase, or different classes of use. Different classes of use could be because of needs for different characteristics, or because of rate schedule as in the case of controlled water heater service.

Note: On a farm or any place that must depend partially or wholly on a local motor-driven pump for fire protection, it is advisable to connect that motor in such a way that the opening of other than its own circuit protection will not interrupt service to the pump.

E-230.003. Service from one Building Through Another.

No overhead service, no underground service, and no service from an isolated plant shall supply one building through another, unless such buildings are under single occupancy or management. Conductors in conduit or duct placed under at least two inches of concrete beneath a building, or buried in two inches of brick masonry or in concrete within a wall, shall be considered outside the building.

B. Insulation and Size of Service Conductors

E-230.004. Insulation of Service Conductors.

Service conductors shall have an insulating covering which will normally withstand exposure to atmospheric and other conditions of use and which shall prevent any detrimental leakage of current to adjacent conductors, objects, or the ground.

Exception. Grounded Conductor. In the case of service conductors that have a nominal voltage to ground of not more than 300 volts, a grounded service conductor without an insulating covering may be installed.

Note 1. For Service Drops - See E-230.022.

Note 2. For Service Entrance Conductors - See E-230.040.

Note 3. For Underground Services - See E-230.030.

E-230.005. Size of Service Conductors.

Service conductors shall have adequate current-carrying capacity to safely conduct the current for the loads supplied without a temperature rise detrimental to the insulating covering of the conductors, and shall have adequate mechanical

strength.

Note: Minimum sizes are given in the following references:

For Service Drops - E-230.023.

For Service Entrance Conductors - E-230.041.

For Underground Service Conductors - E-230.041.

C. Service Drops

E-230.021. Number of Drops.

No building shall be supplied through more than one service drop, except for the purposes listed in E-230.002.

E-230.022. Service Drop Conductors.

(1) Conductors in multiple-conductor cables shall be rubber-covered or thermoplastic-covered except a grounded conductor may be uninsulated where the maximum voltage to ground of any conductor is not over 300 volts.

(2) All open, individual conductors shall be rubber-covered, thermoplastic-covered, or weatherproof-covered.

E-230.023. Minimum Size of Service Drop Conductors.

Conductors in service drops shall be not smaller than No. 8 when of soft copper, or No. 12 when of medium or hard-drawn copper.

Note: Conductors to a building from a pole on which a meter or service switch is installed shall be considered as a service drop and installed accordingly.

E-230.024. Clearance of Service Drop.

Service drops shall not be readily accessible and, for voltages not in excess of 600 volts, shall conform to the following: Paragraphs (1)-(5) inclusive.

For clearance of conductors of over 600 volts, see E-123.03.

(1) Clearance Over Roof. Conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass, except that where the voltage between conductors does not exceed 300 volts and the pitch of the roof is greater than 3" per foot,

walked upon, the clearance may be not less than 3 feet. Where the service conduit extends through a roof, the service drop conductors, if operating at less than 300 volts between conductors, may have a clearance of not less than 18 inches vertically above the roof providing such conductors do not extend more than 45 inches across the roof.

(2) Clearance from Ground. Conductors shall have a clearance of not less than 10 feet from the ground or from any platform or projection from which they might be reached. See rules E-123.03 and E-730.18.

(3) Clearance from Building Openings. Conductors shall have a clearance of not less than 36 inches from windows, doors, porches, fire escapes, or similar locations. The clearance from windows refers only to those portions of windows which are normally capable of being opened. Conductors run above a window are considered inaccessible from that window. No clearance is required from windows consisting of glass blocks or fixed panes which cannot be opened.

(4) Clearance over Storage Tanks. Open conductors shall not pass over flammable liquids storage tanks. Such conductors operating at more than 300 volts to ground shall be kept at least 15 feet horizontally from such tanks. When the voltage is 300 or below, a horizontal clearance of not less than 8 feet shall be maintained.

(5) Clearance from Wells. Service drops shall not pass over wells and shall be kept at least 5 feet horizontally from such wells.

E-230.025. Supports over Buildings.

Where practicable, conductors passing over a building shall be supported on structures which are independent of the building. Where necessary to attach conductors to roof they shall be supported on substantial structures.

E-230.026. Point of Attachment to Buildings.

The point of attachment of a service drop to a building shall be not less than 10 feet above finished grade and shall be at a height to permit a minimum clearance for service drop conductors as specified in E-730.18, "Clearance From Ground". The attachment should not be more than 30 feet above ground, unless a greater height is necessary for proper clearance.

E-230.027. Means of Attachment.

Multiple-conductor cables used for service drops shall be attached to buildings by fittings approved for the purpose. Open conductors shall be attached to non-combustible, nonabsorptive insulators securely attached to the building, or by fittings approved for the purpose.

D. Underground Services

E-230.030. Insulation - Underground Service Conductors.

(1) Underground conductors up to the point of attachment to service equipment shall be covered with rubber, cambric, thermoplastic, paper or other approved insulating material, except:

Exception No. 1. Uninsulated grounded neutral conductors of aluminum or copper may be installed underground when part of an approved cable assembly.

Exception No. 2. Bare grounded neutral conductors of copper may be installed underground in duct or conduit.

(2) Insulated service conductors installed underground, or in concrete slabs or masonry in direct contact with earth, shall be lead-covered or of other types specially approved for the purpose.

E-230.031. Size of Underground Service Conductors.

Same as required for service entrance conductor. See E-230.041.

E-230.032. Protection Against Damage.

(1) In the Ground. Underground service conductors shall be protected against physical damage by being installed in duct, conduit, in cable of one or more conductors approved for the purpose, or by other approved means. See E-310.01(2).

(2) On Poles. Where underground service conductors are carried up a pole the mechanical protection shall be installed to a point at least 8 feet above the ground. Such mechanical protection may be provided by the use of approved cable, pipe, or other approved means.

(3) Where Entering Building. Underground service conductors shall have mechanical protection in the form of rigid or flexible conduit, electrical metallic tubing, auxiliary gutters, the metal tape of an approved service cable, or other approved means. The mechanical protection shall extend to the enclosure for the service equipment unless the service switch is installed on a switchboard, in which case a bushing shall be provided which, except where lead-covered conductors are used, shall be of the insulating type.

E-230.033. Raceway Seal.

Where a service raceway or duct enters from an underground distribution system, the end within the building shall be sealed with suitable compound so as to prevent the entrance of moisture or gases. Spare or unused ducts shall also be sealed.

E-230.034. Grounding Raceways and Cable Sheaths.

See E-230.063.

E-230.035. Termination at Service Equipment.

See E-230.042, Exception No. 3, and E-230.053.

E. Service-Entrance Conductors

E-230.040. Insulation of Service-Entrance Conductors.

(1) Service-entrance conductors extending along the exterior of or entering buildings shall be rubber-covered or thermoplastic-covered if in raceways, or in cables approved for the purpose, except a grounded conductor may be uninsulated where the maximum voltage to ground of any conductor is not over 300 volts.

(a) Where on the exterior of the building only, the conductors may be weatherproof-covered.

(2) Open individual conductors which enter the building shall be rubber-covered or thermoplastic-covered.

E-230.041. Size of Service-Entrance Conductors.

Service-entrance conductors, including underground services, shall have a current-carrying capacity sufficient to carry the load as determined by Chapter

E-220 and in accordance with Tables E-310.12, E-310.13, E-310.14, E-310.15. Service entrance conductors shall not be smaller than No. 6 except:

Exception No. 1. For single family residences requiring more than two 2-wire branch circuits and for multi-occupancy buildings requiring more than two 2-wire branch circuits, the service shall be a minimum of 100 amperes, 3-wire, and each unit requiring more than two 2-wire branch circuits shall have a 3-wire service.

Exception No. 2. For installations consisting of not more than two 2-wire branch circuits they shall not be smaller than No. 8.

Exception No. 3. By special permission due to limitations of supply source or load requirements they shall not be smaller than No. 8.

Exception No. 4. For installations to supply only limited loads of a single branch circuit, such as small polyphase power, controlled water heaters and the like, they shall not be smaller than the conductors of the branch circuit and in no case smaller than No. 12.

Exception No. 5. The neutral conductor which shall have a current-carrying capacity in conformity with E-220.04(5), but shall not be smaller than the ungrounded conductors when these are No. 8 or smaller.

E-230.042. Service-Entrance Conductors Without Splice.

Service-entrance conductors shall be without splice except as follows:

Exception No. 1. Clamped or bolted connections in a meter enclosure are permitted.

Exception No. 2. Taps to main service conductors are permitted as provided in E-230.002, Exception No. 3(b) or to individual sets of service equipment as provided in E-230.070.

Exception No. 3. A connection is permitted, when properly enclosed, where an underground service conductor enters a building and is to be extended to the service equipment or meter in another form of approved service raceway or service cable.

Exception No. 4. A connection is permitted where service conductors are extended from a service drop to an outside meter location and returned to connect to the service entrance conductors of an existing installation.

Exception No. 5. For extending existing services, special permission to make splices in fittings of the service run and to extend existing wire size may be granted.

E-230.043. Other Conductors in Service Raceway.

Conductors other than service conductors, grounding conductors, or control conductors from time switches having overcurrent protection, shall not be installed in the same service raceway or service entrance cable.

Note 1. Water heater leads are to be considered as service entrance conductors.

Note 2. Where a meter is located on a pole the wires to and from the meter may be installed in the same raceway if service equipment is provided at each building supplied from this pole.

F. Installation of Service-Entrance Conductors

E-230.044. Wiring Methods.

Service-entrance conductors extending along the exterior, or entering buildings, may be installed as separate conductors, in cables approved for the purpose, or enclosed in rigid conduit, or, for circuits not exceeding 600 volts, in electrical metallic tubing or as busways.

Note: Service-entrance conductors shall not be run within the hollow spaces of frame buildings unless provided with overcurrent protection at their outer end.

E-230.045. Conductor Considered Outside Building.

Conductors in conduit or duct placed under at least two inches of concrete beneath a building, or buried in two inches of brick masonry or in concrete within a wall, shall be considered outside the building.

E-230.046. Mechanical Protection.

Individual open conductors or cables other than approved service-entrance

cables, shall not be installed within 8 feet of the ground or where exposed to physical damage. Service-entrance cables, where liable to contact with awnings, shutters, swinging signs, installed in exposed places in driveways, near coal chutes or otherwise exposed to physical damage, shall be of the protected type or be protected by conduit, electrical metallic tubing or other approved means.

E-230.047. Individual Open Conductors Exposed to Weather.

Individual open conductors exposed to weather shall be supported on insulators, racks, brackets, or other means, placed at intervals not exceeding 9 feet and separating the conductors at least 6 inches from each other and 2 inches from the surface wired over; or at intervals not exceeding 15 feet if they maintain the conductors at least 12 inches apart. For 300 volts or less, conductors may have a separation of not less than 3 inches where supports are placed at intervals not exceeding 4½ feet and conductors are not less than 2 inches from the surface wired over. Weatherproof conductors (type WP) on exterior of buildings shall have a clearance from the ground of not less than 8 feet, and a clearance from windows, doors, porches, etc., of not less than 3 feet. Conductors run above the top level of a window are considered out of reach from that window.

E-230.048. Individual Open Conductors Not Exposed to Weather.

Individual open conductors not exposed to the weather may be supported on glass or porcelain knobs placed at intervals not exceeding 4½ feet and maintaining the conductors at least one inch from the surface wired over and a separation of at least 2½ inches between conductors.

E-230.049. Individual Conductors Entering Buildings.

Individual conductors entering buildings shall pass inward and upward through slanting noncombustible, nonabsorptive insulating tubes, or shall enter through roof bushings, and shall conform to the provisions of Chapter E-324. Drip loops shall be formed on the conductors before entering tubes.

E-230.050. Service Cables.

Service cables of a type not approved for mounting in contact with a building

shall have insulating supports at intervals not exceeding 15 feet, and maintaining a distance of at least 2 inches from the surface wired over. Service cables mounted in contact with the building shall be supported at intervals not exceeding 4½ feet.

E-230.051. Service Head.

Service raceways shall be equipped with a raintight service head. Service cables, unless continuous from pole to service equipment or meter, shall be equipped with an approved raintight service head, or be formed in a gooseneck, taped and painted or taped with self-sealing weather-resistant thermoplastics and held securely in place by its connection to service-drop conductors below the gooseneck or by a fitting approved for the purpose. Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall be connected to the service-drop conductors below the level of the service head or the termination of service-entrance cable sheaths. Where service heads are used, conductors of opposite polarity shall be brought out through separately bushed holes. *

E-230.052. Enclosing Raceways Made Raintight.

When rigid metal raceways are installed where exposed to weather the raceways shall be made raintight and arranged to drain.

E-230.053. Terminating Raceway at Service Equipment.

Where conduit, electrical metallic tubing, or service cable is used for service conductors, the inner end shall enter a terminal box or cabinet, or be made up directly to an equivalent fitting, enclosing all live metal parts, except that where the service disconnecting means is mounted on a switchboard having exposed bus-bars on the back, the raceway may be equipped with a bushing which shall be of the insulating type unless lead-covered conductors are used.

E-230.054. Grounding Service Raceways and Cable Armor.

See E-230.063.

* Service head and service-drop attachments shall be so located that no part of the drip loops or service-drop conductors within 3 feet of the service head and service drop attachments shall be less than 12 inches from communication cables or conductor attached to or carried along the surface of a building.

G. Service Equipment

E-230.060. Hazardous Locations.

Service equipment installed in hazardous locations shall comply with the requirements of Chapters E-500 to E-517 inclusive.

E-230.061. Service Equipment Grouped.

Where supplied at the same side of the building by more than one overhead service drop or more than one set of underground service conductors, the service equipments, except for services as permitted in E-230.002, shall be grouped and equipment marked to indicate the load it serves.

H. Grounding and Guarding

E-230.062. Guarding.

Live parts of service equipment shall be enclosed so that they will not be exposed to accidental contact, unless mounted on a switchboard, panelboard or controller accessible to qualified persons only and located in a room or enclosure free from easily ignitible material. Such an enclosure shall be provided with means for locking or sealing doors giving access to live parts.

E-230.063. Grounding and Bonding.

Service equipment shall be grounded as follows:

(1) Equipment. The enclosure for service equipment shall be grounded in the manner specified in Chapter E-250, unless (a) the voltage does not exceed 150 volts to ground and such enclosures are (b) isolated from conducting surfaces, and (c) unexposed to contact by persons or materials that may also be in contact with other conducting surfaces.

(2) Raceways. Service raceways, and the metal sheath of service cables, shall be grounded. Conduit and metal pipe from underground supply shall be considered sufficiently grounded where containing lead-sheathed cable bonded to a continuous underground lead-sheathed cable system.

(3) Flexible Conduit. Where a service run of rigid metal raceway is interrupted by flexible metal conduit, the sections of rigid metal raceway thus

interrupted shall be bonded together by a copper conductor not smaller than No. 8, using clamps or other approved means. The conductor and bonding devices shall be protected from physical damage. Where the flexible conduit runs to the service cabinet, similar bonding shall be installed between the cabinet and the rigid raceway.

J. Disconnecting Means

E-230.070. General

Each set of service-entrance conductors shall be provided with a readily accessible means of disconnecting all conductors from the source of supply.

(1) Switch and Circuit-Breaker.

(a) The disconnecting means shall be manually operable. It may consist of not more than six* switches or six* circuit-breakers in a common enclosure, or in a group of separate enclosures, located at a readily accessible point nearest to the entrance of the conductors, either inside or outside the building wall. Two or three single pole switches or breakers, capable of individual operation, may be installed on multi-wire circuits, one pole for each ungrounded conductor, as one multi-pole disconnect (where applicable, see rule E-230.053) provided they are equipped with "handle ties", "handles within 1/16 inch proximity", a "master handle", or "other means", making it practical to disconnect all conductors of the service with no more than six* operations of the hand. The disconnecting means shall be of a type approved for service equipment and for prevailing conditions.

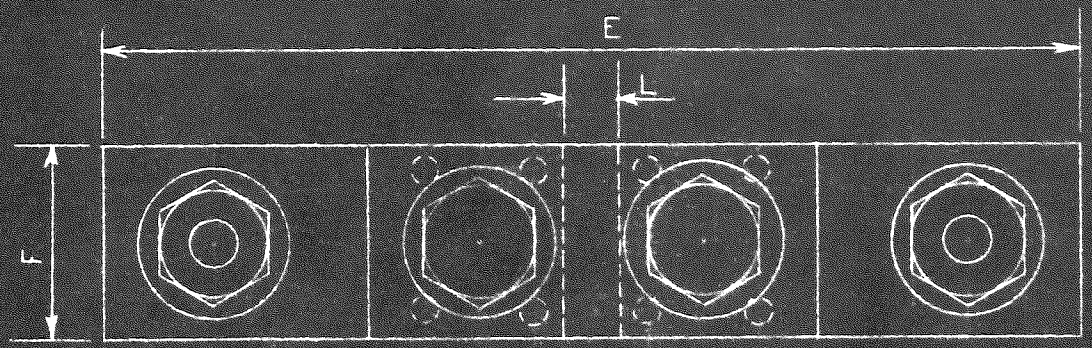
(b) For service operating at not to exceed 250 volts and capacities up to and including 100 amperes, the service switch and service fuses, when not a part of a switchboard, shall be of the accessible fuse or dead front type in which the fuses are dead when accessible and no live parts are exposed to accidental contact.

* Main disconnects for fire pumps, emergency lighting or fire alarm systems shall not be counted as disconnecting means so far as the limit of six disconnecting means is concerned.

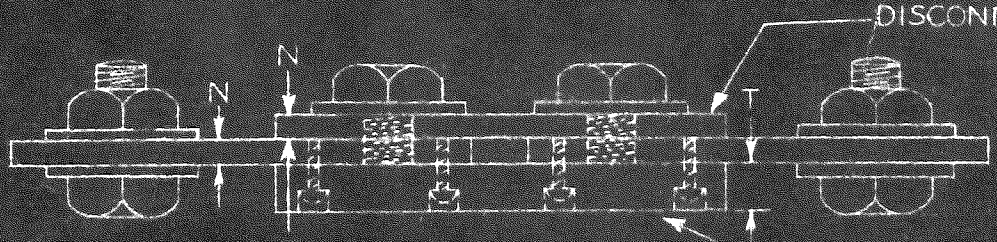
(c) Where the meter is not of the socket type or where current transformers or large self-contained meters are used, the main disconnecting means may consist of not more than six* switches or manually-operated circuit-breakers, provided one of the following disconnecting means is installed ahead of the meter or the metering transformers:

1. An approved bolted link type disconnecting means for services not to exceed 250 volts and for capacities up to and including 400 amperes.

* Main disconnects for fire pumps, emergency lighting or fire alarm systems shall not be counted as disconnecting means so far as the limit of six disconnecting means is concerned.



PLAN VIEW



SIDE VIEW

MATERIAL

INSULATING BASE - APPROVED CLASS "A" INSULATION
STUDS, BOLTS, NUTS & WASHERS - BRASS
BARS AND LINK - COPPER BUS CONDUCTOR

AMP	E	F	L	N	T
200	8 5/8"	1 3/4"	5/8"	1/4"	1/2"
400	10"	2"	3/4"	1/4"	1/2"

CONSTRUCTION SPECIFICATIONS
BOLTED LINK TYPE DISCONNECTING MEANS

E-230.070(1)(c)1.a

2. Manually operated disconnecting switches or circuit-breakers.

a. For services rated 250 volts or less having a capacity above 400 amperes.

b. For all services rated in excess of 250 volts.

Note: If such disconnecting means is incapable of being operated under full load, the service on which it is installed must be sealed or otherwise rendered inaccessible to other than qualified persons.

(2) Multiple-Occupancy. In a multiple-occupancy building, each occupant shall have access to his disconnecting means. A multiple-occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the disconnecting means consisting of not more than six* switches or six* circuit-breakers. Multiple-occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy in accordance with E-230.002(Exception No. 3) and each such service may have not more than six* switches or circuit-breakers.

(3) Disconnection of Grounded Conductor. If the switch or circuit-breaker does not interrupt the grounded conductor, other means shall be provided in the service cabinet or on the switchboard for disconnecting the grounded conductor from the interior wiring.

(4) More Than One Building. In a property comprising more than one building under single management, the conductors supplying each building served shall be provided with a readily accessible means, within or adjacent to the building, of disconnecting all ungrounded conductors from the source of supply. In garages and outbuildings on residential property the disconnecting means may consist of a snap switch, suitable for use on branch circuits, including switch controls at more than one point.

* Main disconnects for fire pumps, emergency lighting or fire alarm systems shall not be counted as disconnecting means so far as the limit of six disconnecting means is concerned.

(5) Safeguarding Emergency Supply. If an emergency supply is provided to feed the conductors controlled by the service disconnecting means, the disconnector shall be of a design that will open all ungrounded conductors from the usual supply before connection is made to the emergency supply, unless agreed upon arrangements have been made for parallel operation and suitable automatic control equipment provided.

E-230.071. Rating of Service Equipment.

(1) The service disconnecting means shall have a rating not less than the load to be carried determined in accordance with Chapter E-220. In general the service disconnecting means shall have a rating of not less than 60 amperes where a switch is used, and not less than 50 amperes where a circuit-breaker is used, except:

Exception No. 1. For single family residences requiring more than two 2-wire branch circuits and for multi-occupancy buildings requiring more than two 2-wire branch circuits, the service equipment shall have a rating of not less than 100 amperes.

Exception No. 2. For installations consisting of not more than two 2-wire branch circuits a service equipment of 30 ampere minimum rating may be used.

Exception No. 3. For installations consisting of a single branch circuit a circuit-breaker of 15 or 20 ampere rating may be used.

(2) Where multiple switches or circuit breakers are used in accordance with E-230.070(1), the combined rating shall not be less than required for a single switch or breaker.

E-230.072. Connection to Terminals.

The service conductors shall be attached to the disconnecting means by pressure connectors, clamps or other approved means, except that connections which depend upon solder shall not be used.

E-230.073. Connections Ahead of Disconnecting Means.

Service fuses, meters, high-impedance shunt circuits (such as potential coils of meters, etc.), supply conductors for time switches, surge protective capacitors, instrument transformers, lightning arresters and circuits for emergency systems, fire pump equipment, fire and sprinkler alarms as provided in E-230.094, may be

on the supply side of the disconnecting means. Taps from service conductors to supply time switches, circuits for emergency lighting, etc., shall be installed in accordance with E-230.044 and disconnecting means shall be installed as required in E-230.070.

Note: For detailed service provisions for fire alarm, sprinkler supervisory, or watchman systems, see appropriate Standards of the National Fire Protection Association.

K. Overcurrent Protection

E-230.090. Where Required.

Each ungrounded service-entrance conductor shall have overcurrent protection.

(1) Ungrounded Conductor. Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor, having a rating or setting not higher than the allowable carrying capacity of the conductor, except as follows:

Exception No. 1. For motor-starting currents, ratings in conformity with E-430.052, E-430.062, or E-430.063 may be used.

Exception No. 2. Circuit-breakers may have a setting in conformity with E-240.05, Exception No. 2 and E-240.07.

Exception No. 3. Not more than six* circuit-breakers or six sets of fuses may serve as the overcurrent device.

Exception No. 4. In a multiple occupancy building each occupant shall have access to his overcurrent protective devices. A multiple occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the overcurrent protection consisting of not more than six* circuit-breakers or six sets of fuses. Multiple occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy in accordance with E-230.002, Exception No. 3(b) and each such service may have not more than six* circuit-breakers or six sets of fuses.

Note: A set of fuses is all the fuses required to protect all the ungrounded conductors of a circuit. Single pole breakers may be grouped as in E-230.070(1) as one multiple protective device.

*Main disconnects for fire-pumps, emergency lighting or fire alarm systems shall not be counted as disconnecting means so far as the limit of six disconnecting means is concerned.

(2) Not in Grounded Conductor. No overcurrent device shall be inserted in a grounded service conductor except a circuit-breaker which simultaneously opens all conductors of the circuit.

(3) More Than One Building. In a property comprising more than one building under single management, the ungrounded conductors supplying each building served shall be protected by overcurrent devices, which may be located in the building served or in another building on the same property, provided they are accessible to the occupants of the building served.

E-230.091. Location. The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto, unless located at the outer end of the entrance.

E-230.092. Location of Branch-Circuit Overcurrent Devices.

Where the service overcurrent devices are locked or sealed, or otherwise not readily accessible, branch-circuit overcurrent devices shall be installed on the load side, shall be mounted in an accessible location and shall be of lower rating than the service overcurrent device.

E-230.093. Protection of Specific Circuits.

Where necessary to prevent tampering, an automatic overcurrent device protecting service conductors supplying only a specific load such as a water heater, may be locked or sealed where located so as to be accessible.

E-230.094. Relative Location of Overcurrent Device and Other Service Equipment.

The overcurrent device shall protect all circuits and devices except as follows:

(1) The service switch may be placed on the supply side.

(2) High impedance shunt circuits (such as potential coils of meters, etc.), lightning arresters, surge protective capacitors, and instrument transformers, may be connected and installed on the supply side of the service disconnecting means as permitted in E-230.073.

(3) Circuits for emergency supply and time switches may be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

(4) Circuits used only for the operation of fire alarm, other protective signalling systems, or the supply to fire pump equipment may be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

(5) Meters for alternating current service not in excess of 600 volts, provided the service contains a grounded conductor and the cases and enclosures of such meters are grounded by connection to the grounded circuit conductor (see E-250.061) or to a common system and equipment ground electrode (see E-250.054); or meters for alternating current service not containing a grounded service conductor and not in excess of 300 volts.

L. Services Exceeding 600 Volts

E-230.100 Scope.

Service conductors and equipment used on circuits exceeding 600 volts shall comply with the applicable provisions of the preceding rules of this Chapter and with the following rules which are additions to or modifications of the preceding rules.

Note 1. Secondary conductors, not the primary conductors, are regarded as constituting the service conductors to the building proper in the following cases:

a. Where step-down transformers are located outdoors.

b. Where step-down transformers are located in a separate building from the one served.

c. Where step-down transformers are located in the building served in a transformer vault conforming to the requirements of rules E-450.41 to

* d. E-450.48, and under the sole control of the supply company.

Note 2. In no case will the provisions of this Chapter apply to equipment not

* Where the transformer primary disconnecting means is in a locked enclosure, accessible to authorized personnel alone.

directly connected to service conductors, and consequently will not apply to equipment in vaults under the sole control of the supply company.

E-230.101. Service-Entrance Conductors.

(1) Conductor Size. Service conductors shall be not smaller than No. 6 unless in cable. Conductors in cable shall be not smaller than No. 8.

(2) Wiring Methods. In locations accessible to other than qualified persons service-entrance conductors of more than 600 volts shall be installed in rigid conduit, or as multiple conductor cable approved for the purpose.

(3) Open Work. If open work is employed where not accessible to other than qualified persons, the service conductors shall be rigidly supported on glass, porcelain or other insulators approved for the purpose, which will keep them at least 8 inches apart, except at terminals of equipment. They shall be not less than 2 inches from the surfaces wired over and for voltages exceeding 2,500 not less than 3 inches.

(4) Supports. Service conductors and their supports, including insulators, shall have strength and stability sufficient to insure maintenance of adequate clearance with abnormal currents in case of short circuits.

(5) Guarding. Open wires shall be guarded where accessible to unqualified persons.

(6) Service Cable. Where cable conductors emerge from a metal sheath or raceway, the insulation of the conductors shall be protected from moisture and physical damage by a pothead or other approved means.

(7) Draining Raceways. Unless conductors specifically approved for the purpose are used, raceways embedded in masonry, or exposed to the weather, or in wet locations shall be arranged to drain.

(8) Over 15,000 Volts. Where the voltage exceeds 15,000 volts between conductors they shall enter a transformer vault conforming to the requirements of E-450.41 to E-450.48.

(9) Enclosed by Concrete or Brick. Conductors in conduit or duct and enclosed by concrete or brick not less than 2 inches thick shall be considered outside the building.

E-230.102. Warning Signs.

High voltage signs shall be posted where unauthorized persons might come in contact with live parts.

E-230.103. Disconnecting Means.

The circuit-breaker or the alternatives for it specified in E-230.106 will constitute the disconnecting means required by E-230.070.

E-230.104. Isolating Switches.

Isolating switches shall be provided as follows:

(1) Air-break isolating switches shall be installed between oil switches or air or oil circuit-breakers used as service switches and the supply conductor, except where such equipment is mounted on removable truck panels or metal-enclosed switchgear units which cannot be opened unless the circuit is disconnected, and which, when removed from the normal operating position, automatically disconnect the circuit-breaker or switch from all live parts.

(2) When the fuses used with non-automatic oil switches in accordance with E-230.106 are of a type that may be operated as a disconnect switch, they may serve as the isolating switch when they completely disconnect the oil switch and all service equipment from the source of supply.

(3) Air-break isolating switches shall be accessible to qualified attendants only. They shall be arranged so that a grounding connection on the load side can readily be made. Such grounding means meed not be provided for duplicate isolating switches, if any, installed and maintained by the supply company.

E-230.105. Equipment in Secondaries.

If the primary service equipment supplies one or more transformers whose secondary windings feed a single set of mains, and the primary circuit-breaker is

manually operable from a point outside the transformer vault or accessible to qualified persons only, the disconnecting means and overcurrent protection may be omitted from the secondary circuit, provided the setting of the primary circuit-breaker is such as to protect the secondary circuit. If not manually operable from outside the vault, means shall be provided to trip the breaker from outside the vault. In all other cases the secondary circuit shall be provided with a disconnecting means and overcurrent protection as required by various paragraphs of this rule.

Note: "Manually operable" calls for a mechanical, rather than only electrical, linkage between the circuit-breaker and the point of operation, and refers to both the opening and closing operations.

E-230.106. Overcurrent Protection.

Overcurrent devices shall be provided in accordance with the following:

(1) In Vault or Consisting of Metal-Enclosed Switchgear. Where the service equipment is installed in a transformer vault meeting the provisions of E-450.41 to E-450.48, or consists of metal-enclosed switchgear, the requirements for overcurrent protection and disconnecting means may be fulfilled by the following:

(a) On circuits of 15,000 volts or less, oil-filled or other fuses of suitable rating and type may be used without switch or circuit-breaker provided they may be operated as a disconnecting means.

(b) Where the voltage is 25,000 or less, a non-automatic oil switch, an air load-interrupter switch, or other approved switches, capable of interrupting the rated circuit load and suitable fuses may be used.

(c) Automatic-trip circuit-breakers may also be used under the limitations outlined in E-230.106(1)(a) and (b). Where these limitations are exceeded, an automatic-trip circuit-breaker shall be installed in compliance with the requirements of E-230.106(2).

(d) Where the voltage is 15,000 or less, a switch capable of interrupting

the no-load current of the transformer and suitable fuses may be used, provided the switch is interlocked with a circuit-breaker in the secondary circuit of the transformer so that the switch cannot be opened when the circuit-breaker is closed.

(e) Vaults shall conform to the provisions of E-450.41 to E-450.48.

(f) Metal-enclosed switchgear shall consist of a substantial steel structure and a steel enclosure of thickness not less than 1/8 inch, over the sides and top. The enclosure shall be furnished as an integral part of the equipment. Where installed over a wood floor, suitable protection thereto shall be provided.

(2) Where the service equipment is not in a vault or metal enclosure, requirement for the overcurrent protection and disconnecting means may be fulfilled by the following:

(a) Circuits of not over 25,000 volts, air load-interrupter switches or other approved switches, capable of interrupting the rated circuit load may be used with suitable fuses on a pole outside the building.

(b) On circuits of any voltage, an automatic trip circuit-breaker of suitable current-carrying and interrupting capacity with an overcurrent unit in each ungrounded conductor and so arranged that the operation of any one device will open all ungrounded conductors may be used. The circuit-breaker shall be located as near as possible to where the service conductors enter the building, or else on a pole outside the building.

(3) Fuses. Fuses used as permitted in E-230.106(1) and (2) shall have an interrupting rating at least equal to the maximum short-circuit current possible in the circuit.

(4) Circuit-Breakers. Circuit-breakers shall be free to open in case the circuit is closed on an overload. This can be accomplished by means such as trip-free breakers or by multiple breakers having an operating handle per pole. A service circuit-breaker shall indicate clearly whether it is open or closed, and shall be capable of interrupting the maximum short-circuit current to which it may be sub-

jected.

E-230.107. Lightning Arresters.

Lightning arresters installed in accordance with the requirements of Chapter E-280 shall be placed on each ungrounded overhead service conductor on the supply side of the service equipment, when called for by the administrative authority.

CHAPTER E-240

OVERCURRENT PROTECTION

A. Installation

E-240.01. Scope.

This Chapter provides the general requirements for the application of overcurrent protective devices.

E-240.02. Purpose of Overcurrent Protection.

Overcurrent protection for conductors and equipment is provided for the purpose of opening the electric circuit if the current reaches a value which will cause an excessive or dangerous temperature in the conductor or conductor insulation.

E-240.03. Protection of Equipment.

Equipment shall be protected against overcurrent as specified in the references in the following table:

Equipment	Chapter No.
Appliances	E-422
Capacitors	E-460
Cranes and Hoists	E-610
Elevators, Dumbwaiters and Escalators	E-620
Emergency Systems	E-700
Generators	E-445
Inductive and Dielectric Heat Generating Equipment	E-665
Machine Tools	E-670
Motion Picture Studios and Similar Locations	E-530
Motors and Motor Controllers	E-430
Organs	E-650
Over 600 Volts	E-710
Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits	E-725
Services	E-230
Signs and Outline Lighting	E-600
Sound Equipment	E-640
Switchboards and Panelboards	E-384
Theaters and Assembly Halls	E-520
Transformers	E-450
Welders	E-630
X-ray Equipment	E-660

E-240.04. Time-Delay Overcurrent Protection.

Circuit breakers and plug fuses installed in residential occupancies on circuits of 20 amperes or less shall be of the time-delay type.

E-240.05. Overcurrent Protection of Conductors.

Conductors shall be protected in accordance with their current-carrying capacities, as given in Tables E-310.12 through E-310.15, except as follows:

Exception No. 1. Rating of Overcurrent Protection. When the standard ampere ratings and settings of overcurrent devices do not correspond with the allowable current-carrying capacities of conductors, the next higher standard rating and setting may be used.

Exception No. 2. Adjustable-Trip Circuit Breakers. Adjustable-trip circuit-breakers of the thermal trip, magnetic time-delay trip or instantaneous-trip types shall be set to operate at not more than 125 per cent of the allowable current-carrying capacity of the conductor.

Note: The effect of the temperature on the operation of thermally-controlled circuit-breakers should be taken into consideration in the application of such circuit-breakers when they are subjected to extremely low or extremely high temperatures.

Exception No. 3. Fixture Wires and Cords. Fixture wire or flexible cord, sizes No. 16 or No. 18, and tinsel cord shall be considered as protected by 20-ampere overcurrent devices except as provided in E-620.61. Fixture wires of the sizes permitted for taps in E-210.19(3)(b) shall be considered as protected by the overcurrent protection of the 30-ampere and 50-ampere branch circuits of Chapter E-210. Flexible cord approved for use with specific appliances shall be considered as protected by the overcurrent device of the branch circuit of Chapter E-210 when conforming to the following:

20 ampere circuits, No. 18 cord and larger.

30 ampere circuits, cord of 10 amperes capacity and over.

50 ampere circuits, cord of 20 amperes capacity and over.

Exception No. 4. Motor Circuits. The conductors supplying motors and motor-operated appliances shall be considered as protected by the overcurrent protective devices specified in E-430.032, E-430.034, E-430.052, E-430.053 and E-430.062.

Exception No. 5. Remote Control. Except as provided in Chapter E-725, the conductors of the control circuits of remote-control switches shall be considered as protected from overcurrent by overcurrent devices that are not of the so-called time-lag type and are rated or set at not more than 500 per cent of the carrying capacity of the remote-control conductors, as specified in Tables E-310.12 through E-310.15.

Exception No. 6. Public highway traffic signal circuits whose conductors are not overloaded may be protected by overcurrent devices rated or set at not more than 200 per cent of the carrying capacity of the conductors, as specified in Tables E-310.12 through E-310.15.

E-240.06. Fuses.

(1) If the allowable current-carrying capacity of a conductor does not correspond to the rating of a standard-size fuse, the next larger size or rating of fuse may be used.

(2) Standard ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000. Fuses with ampere rating other than the standard rating listed may be used when they are of an ampere rating smaller than those included in the standard list.

(3) Plug fuses and fuse holders shall not be used in circuits exceeding 125 volts between conductors except in circuits supplied from a system having a grounded neutral and no conductor in such circuits operating at more than 150 volts to ground.

(4) The screw-shell of plug-type fuse holders shall be connected to the load side of the circuit.

E-240.07. Non-Adjustable-Trip Circuit-Breakers.

(1) Non-adjustable-trip circuit-breakers, except as otherwise permitted in Note 10 to Tables E-310.12 through E-310.15 shall be rated in accordance with the current-carrying capacity of the conductor. When the allowable current-carrying capacity of a conductor does not correspond to the rating of a standard-size circuit-breaker, the next larger size or rating of circuit-breaker may be used.

(2) Standard ampere ratings for circuit breakers are 15, 20, 30, 40, 50, 60, 70, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 500, 600, 700 and 800.

E-240.08. Thermal Devices.

Thermal cutouts, thermal relays and other devices not designed to open short-circuits, shall not be used for protection of conductors against overcurrent due to short-circuits or grounds but may be used to protect motor branch circuit conductors from overload if protected in accordance with E-430.040.

E-240.09. Feeders at Supply Stations.

Each conductor of a constant-potential circuit entering or leaving a supply station, except grounded neutral conductors, shall be protected from excessive current by a circuit-breaker, or by an equivalent device of approved design. Such protective devices shall be located as near as practicable to the point where the conductors enter or leave the building. For the outgoing circuits not connected with other sources of power, the protective devices may be placed on the supply side of transformers or similar devices.

E-240.11. Ungrounded Conductors.

(1) An overcurrent device (fuse or overcurrent trip unit of a circuit-breaker) shall be placed in each ungrounded conductor. The number and position of the overcurrent units such as trip coils or relays shall be as given in Table E-240.28.

(2) Circuit-breakers shall open all ungrounded conductors of the circuit, except as follows:

Exception: Individual single-pole circuit-breakers may be used for the protection of each conductor of ungrounded 2-wire circuits, each ungrounded conductor of 3-wire direct-current or single-phase circuits, or for each ungrounded conductor of lighting or appliance branch circuits connected to 4-wire three-phase systems, or 5-wire 2-phase systems, provided such lighting or appliance circuits are supplied from a system having a grounded neutral and no conductor in such circuits operates at a voltage greater than permitted in E-210.06.

E-240.12. Grounded Conductor.

No overcurrent device shall be placed in any permanently grounded conductor, except as follows:

Exception No. 1. Where the overcurrent device simultaneously opens all conductors of the circuit.

Exception No. 2. For motor-running protection as provided in E-430.036 and E-430.037.

E-240.13. Change in Size of Grounded Conductor.

Where a change occurs in the size of the ungrounded conductor, a similar change may be made in the size of the grounded conductor.

E-240.14. Fuses in Multiple.

For the protection of conductors having allowable carrying capacities exceeding the rated capacity of the largest approved cartridge type fuse in E-240.23(1)(a), such cartridge fuses arranged in multiple may be used, provided as few fuses as possible are used and the fuses are of the same type, characteristics, and rating and provided the fuseholder terminals are mounted on a single continuous pair of bus-bars, or have an equivalent arrangement that will eliminate any potential difference between the terminals of the fuses.

B. Location

E-240.15. Location in Circuit.

Overcurrent devices shall be located at the point where the conductor to be

protected receives its supply, except as follows:

Exception No. 1. Service Conductors. An overcurrent protective device for service conductors may be located as specified in E-230.091.

Exception No. 2. Smaller Conductor Protected. Where the overcurrent device protecting the larger conductors also protects the smaller conductors in accordance with Tables E-310.12 through E-310.15.

Exception No. 3. Branch Circuits. Taps to individual outlets and circuit conductors supplying a single household electric range shall be considered as protected by the branch circuit overcurrent devices when in accordance with the requirements of E-210.19 and E-210.20.

Exception No. 4. Taps. A conductor tapped from a feeder shall be considered as properly protected from overcurrent when installed in accordance with E-210.25, E-364.08 and E-430.058.

Exception No. 5. Taps Not Over 10 Feet Long. Where (1) the smaller conductor has a current-carrying capacity of not less than the sum of the allowable current-carrying capacities for the conductors of the one or more circuits or loads supplied, and(2) the tap is not over 10 feet long and does not extend beyond the switchboard, panelboard, or control devices which it supplies, and (3) except at the point of connection to the feeder, the tap is enclosed in conduit, electrical metallic tubing, or in metal gutters when not a part of the switchboard or panelboard.

Exception No. 6. Taps Not Over 25 Feet Long. Where the smaller conductor has a current-carrying capacity at least one-third that of the conductor from which it is supplied, and provided the tap is suitably protected from physical damage, is not over 25 feet long, and terminates in a single circuit-breaker or set of fuses which will limit the load on the tap to that allowed by Tables E-310.12 through E-310.15. Beyond this point the conductors may supply any number of circuit-breakers or sets of fuses.

E-240.16. Location in Premises.

Overcurrent devices shall be located where they will be:

(1) Readily accessible, except as provided in E-230.091 for service equipment, E-364.11 for busways, and E-610.42 for cranes and hoists.

(2) Not exposed to physical damage.

(3) Not in the vicinity of easily ignitible material.

C. Enclosures

E-240.17. Enclosures for Overcurrent Devices.

(1) General. Overcurrent devices shall be enclosed in cutout boxes or cabinets, unless a part of a specially approved assembly which affords equivalent protection, or unless mounted on switchboards, panelboards or controllers located in rooms or enclosures free from easily ignitible material and dampness. The operating handle of a circuit-breaker may be accessible without opening a door or cover.

(2) Damp or Wet Locations. Enclosures for overcurrent devices in damp or wet locations shall be of a type approved for such locations and shall be mounted so there is at least one-fourth inch air space between the enclosure and the wall or other supporting surface.

(3) Vertical Position. Enclosures for overcurrent devices shall be mounted in a vertical position unless in individual instances this is shown to be impracticable.

(4) Rosettes. Fuses shall not be mounted in rosettes.

D. Disconnecting and Guarding

E-240.18. Disconnection of Fuses and Thermal Cutouts Before Handling.

Disconnecting means shall be provided on the supply side of all fuses or thermal cutouts in circuits of more than 150 volts to ground and cartridge fuses in circuits of any voltage, where accessible to other than qualified persons, so that each individual circuit containing fuses or thermal cutouts can be independently disconnected from the source of electrical energy, except as provided in E-230.073

and except that a single disconnecting means may be used to control a group of circuits each protected by fuses or thermal cutouts under the conditions described in E-430.112.

E-240.19. Arcing or Suddenly-Moving Parts.

Arcing or suddenly-moving parts shall comply with the following:

(1) Location. Fuses and circuit-breakers shall be so located or shielded that persons will not be burned or otherwise injured by their operation.

(2) Suddenly-Moving Parts. Handles or levers of circuit-breakers, and similar parts which may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

E. Plug Fuses and Fuseholders

E-240.20. Plug Fuses of the Edison-Base Type.

Plug fuses of the Edison-base type shall conform to the following:

(1) Classification. Plug fuses of this type shall be classified at not over 125 volts, 0 to 30 amperes.

(2) Live Parts. Fuses and fuseholders when installed and assembled together shall have no live parts exposed.

(3) Marking. Plug fuses of 15 amperes rating or less shall be distinguished from those of larger rating by an hexagonal opening in the cap through which the mica or similar window shows, or by some other prominent hexagonal feature such as the form of the top or cap itself, or an hexagonal recess or projection in the top or cap.

E-240.21. Fuseholders for Plug Fuses.

Fuseholders for plug fuses of 30 amperes or less shall not be installed unless they comply with E-240.22 or are made to comply with E-240.22 by the insertion of an adapter.

E-240.22. Plug Fuses and Fuseholders of Type S.

Where Type S plug fuses are to be used as the overcurrent device required by this Code, the fuses and fuseholders shall conform to the following requirements:

(1) Classification. Plug fuses and fuseholders of Type S shall be classified at not over 125 volts; 0 to 15 amperes, 16 to 30 amperes.

(2) Fuses Usable Only in Fuseholders of the Same Classification. Fuses of the 16 to 30 ampere classification shall not be usable with fuseholders or adapters of the 0 to 15 ampere classification.

(3) Fuseholders and Adapters. Fuses, fuseholders, and adapters shall be so designed that a fuse other than a Type S fuse cannot be used in a fuseholder or adapter designed for Type S fuses.

(4) Tamperability. Fuses, fuseholders and adapters shall be so designed as to be subject to tampering or bridging only with difficulty.

(5) Adapters to be Non-Removable. Fuse adapters shall be so designed that when once inserted in a fuseholder they cannot be removed.

(6) Interchangeability. Fuses, fuseholders and adapters of various manufacturers shall be interchangeable with each other, and the plugs with adapters shall be suitable for use in the Edison-base type fuseholder.

(7) Plug Type. Fuses and fuseholders shall be of the plug type.

(8) Ampere Rating. Each fuse, fuseholder and adapter shall be marked with its ampere rating.

(9) Marking. Fuses of the 0 to 15 ampere rating shall be distinguished from those of larger rating by an hexagonal opening in the cap through which the mica or similar window shows, or some other prominent hexagonal feature such as the form of the top or cap itself, or an hexagonal recess or projection in the top or cap.

F. Cartridge Fuses and Fuseholders

E-240.23. Cartridge Fuses and Fuseholders.

Cartridge fuses and fuseholders shall conform to the following:

(1) Classification.

(a) 0-600 ampere cartridge fuses and fuseholders shall be classified as regards current and voltage as follows:

Not over 250 volts Amperes	Not over 600 volts Amperes
0- 30	0- 30
31- 60	31- 60
61-100	61-100
101-200	101-200
201-400	201-400
401-600	401-600

(b) 601-6000 ampere cartridge fuses and fuseholders shall be classified at 600 volts as follows:

601 - 800 amperes
801 - 1200
1201 - 1600
1601 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 6000

Note: There are no 250 volt ratings over 600 amperes, but 600 volt fuses may be used for lower voltages.

(2) Non-interchangeable. 0-6000 ampere cartridge fuses and fuseholders shall be so designed that it will be impossible to put a fuse of any given class into a fuseholder which is designed for a current lower, or voltage higher, than that of the class to which it belongs. Fuseholders for current limiting fuses shall not permit insertion of fuses which are not current limiting.

(3) Marking. Fuses shall be plainly marked with the ampere rating, voltage rating, current-limitation where it applies, and the name or trademark of the maker. The marking shall be either by direct printing on the fuse barrel or by means of an attached label.

G. Link Fuses and Fuseholders

E-240.24. Link Fuses and Fuseholders.

Link fuses and fuseholders shall be used only by special permission and shall conform to the following:

(1) Mounting. Link fuses shall be mounted on approved fuseholders.

(2) Dimensions. Link fuses and fuseholders shall have the following dimensions in inches:

Amperes Capacity	Minimum Separation of Nearest Metal Parts of Opposite Polarity	Minimum Break Distance
Not over 125 volts 601 - 1500	1½	1½
Not over 250 volts 601 - 1500	2-3/4	2

(a) For 3-wire systems, link fuses, and fuseholders shall have the break distance required for circuits of the potential of the outside wires, except that in 125-250 volt systems with grounded neutral the fuses and fuseholders in 2-wire, 125 volt branch circuits may have the spacing specified for not over 125 volts.

(3) Spacing. A space shall be maintained between the fuse terminals of link fuses of the same polarity of at least ½ inch for voltages up to 125, and of at least 3/4 inch for voltages from 126 to 250. This is the minimum distance allowable and greater separation shall be provided where practicable.

(4) Material. Contact surfaces on tops of link fuses shall be of copper or aluminum having good electrical connections with the fusible part of the strip.

(5) Minimum Rating. Link fuses and fuseholders shall be used only in sizes rated at more than 600 amperes, and only by special permission.

(6) Marking. Link fuses shall be stamped with 80 per cent of the maximum current which they can carry indefinitely.

H. Circuit-Breakers

E-240.25. Circuit-Breakers.

Circuit-breakers shall conform to the following:

(1) Method of Operation. In general, circuit-breakers shall be capable of being closed and opened by hand without employing any other source of power, although normal operation may be by other power such as electrical, pneumatic, and the like. Large circuit-breakers which are to be closed and opened by electrical, pneumatic, or other power shall be capable of being closed by hand for maintenance

purposes and shall also be capable of being tripped by hand under load without the use of power.

(2) Type of Operation. Circuit-breakers of the 0-30 ampere class should be of the time-delay type.

(3) Injury to Operator. Circuit-breakers shall be arranged and mounted so that their operation is not likely to injure the operator.

(4) Indication. Circuit-breakers shall indicate whether they are in the open or closed position.

(5) Non-Tamperable. An air circuit-breaker, used for the branch circuits described in Chapter E-210, shall be of such design that any alteration of its trip point (calibration), or in the time required for its operation, will be difficult.

(6) Marking. Circuit-breakers shall be marked with their rating in such a manner that the marking will be visible after installation.

(7) Non-interchangeable Circuit-Breakers. Circuit-breakers used for lighting and appliance branch circuits shall be non-interchangeable in accordance with the following provisions:

(a) Circuit-breakers rated within the range of 0-250 volts, alternating current and not more than 100 amperes shall be classified as regards current as follows:

Amperes
0-20
21-50
51-100

(b) Such circuit-breakers or their multiple mounting and bussing means shall be so arranged that it will be difficult, after a circuit-breaker has been

installed, to replace it with a breaker of a higher ampere classification.

(c) Such circuit-breakers of higher than 0-20 ampere classification shall be difficult to install in the spare spaces which are left for future additions.

E-240.27. Current Limiting Overcurrent Protective Device.

A current limiting overcurrent protective device is a device which, when interrupting a specified circuit, will consistently limit the short-circuit current in that circuit to a specified magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Notes to Table E-240.28

*1. An overcurrent unit may consist of a series overcurrent tripping device or the combination of a current transformer and a secondary overcurrent tripping device. Either two or three secondary overcurrent tripping devices may be used with three current transformers on a 3-phase system similar to those shown in Diagrams 15 and 18.

**2. When three current transformers are used instead of three series overcurrent tripping devices shown in Diagrams 13, 15, 17 and 18, the secondary tripping devices may consist of three secondary overcurrent tripping devices or two secondary overcurrent tripping devices with a residual current tripping device of a lower range. See Diagram 16.

3. Where standard devices are not available with three or four overcurrent

units as required in the Table, it is permissible to substitute two overcurrent units and one fuse where three overcurrent units are called for, two overcurrent units and two fuses where four overcurrent units are called for. The fuse or fuses are to be placed in the conductors not containing an overcurrent unit. This practice, however, of substituting fuses for overcurrent units is to be discouraged for obvious reasons.

Table E-240.28. Number of Overcurrent Units, Such as Trip Coils or Relays, for Protection of Circuits

(See Diagrams 1 to 19 following this Table)

(See E-240.11 for the overcurrent protection of conductors in general, E-230.090 for services, and E-430.037 for motors).

SYSTEMS	*Number and Location of Overcurrent Units
2-Wire, Single-phase A.C. or D.C. Ungrounded.	Two (one in each conductor. Diagram 1).
2-wire, Single-phase, A.C. or D.C., One Wire Grounded	One (in ungrounded conductor. Diagram 2).
2-Wire, Single-phase A.C. or D.C., Mid-point Grounded.	Two (one in each conductor. Diagram 3).
2-Wire, Single-phase A.C. Derived from 3-Phase, with Ungrounded Neutral.	Two (one in each conductor. Diagram 4).
2-Wire, Single-phase Derived from 3-Phase, Grounded Neutral System by Using outside Wires of 3-Phase Circuit.	Two (one in each conductor. Diagram 5).
3-Wire, Single-phase, A.C. or D.C. Ungrounded Neutral	Three (one in each conductor. Diagram 6).
3-Wire, Single-phase A.C. or D.C. Grounded Neutral.	Two (one in each conductor except neutral conductor. Diagram 7).
3-Wire, 2-Phase, A.C. Common Wire Ungrounded.	Three (one in each conductor. Diagram 8).
3-Wire, 2-Phase, A.C., Common Wire Grounded.	Two (one in each conductor except common conductor. Diagram 9).
4-Wire, 2-Phase Ungrounded, Phases Separate.	Four (one in each conductor. Diagram 10).
4-Wire, 2-Phase, Grounded Neutral, or 5-Wire, 2-Phase, Grounded Neutral.	Four (one in each conductor except neutral conductor. Diagrams 11 and 12).
3-Wire, 3-Phase, Ungrounded.	Three (one in each conductor. Diagram 13**).
3-Wire, 3-Phase, 1 Wire Grounded.	Two (one in each ungrounded conductor. Diagram 14).
3-Wire, 3-Phase, Grounded Neutral.	Three (one in each conductor. Diagram 15**).

3-Wire, 3-Phase, Mid-point of one phase grounded.	Three (one in each conductor. Diagram 17**).
4-Wire, 3-Phase, Grounded Neutral.	Three (one in each ungrounded conductor. Diagram 18**).
4-Wire, 3-Phase, Ungrounded Neutral.	Four (one in each conductor. Diagram 19).

Supplementary Overcurrent Protection

E-240.30. Purpose.

Supplementary overcurrent protection may be included in appliances or other utilization equipment to provide individual protection for specific components, or internal circuits within the equipment itself. It does not abrogate any of the requirements applicable to branch circuits and is not to be used as a substitute for branch-circuit protection.

E-240.31. Location.

Supplementary overcurrent devices where provided shall be located in each separate appliance or other equipment and shall not extend to circuits beyond the confines of the equipment.

E-240.32. Accessibility.

Supplementary overcurrent protective devices need not be readily accessible.

E-240.33. Interrupting Capacity.

Supplementary overcurrent protective devices shall be able to interrupt short-circuit currents of the magnitude likely to be encountered by the branch circuit overcurrent protective device protecting that circuit.

E-240.34. Interchangeability.

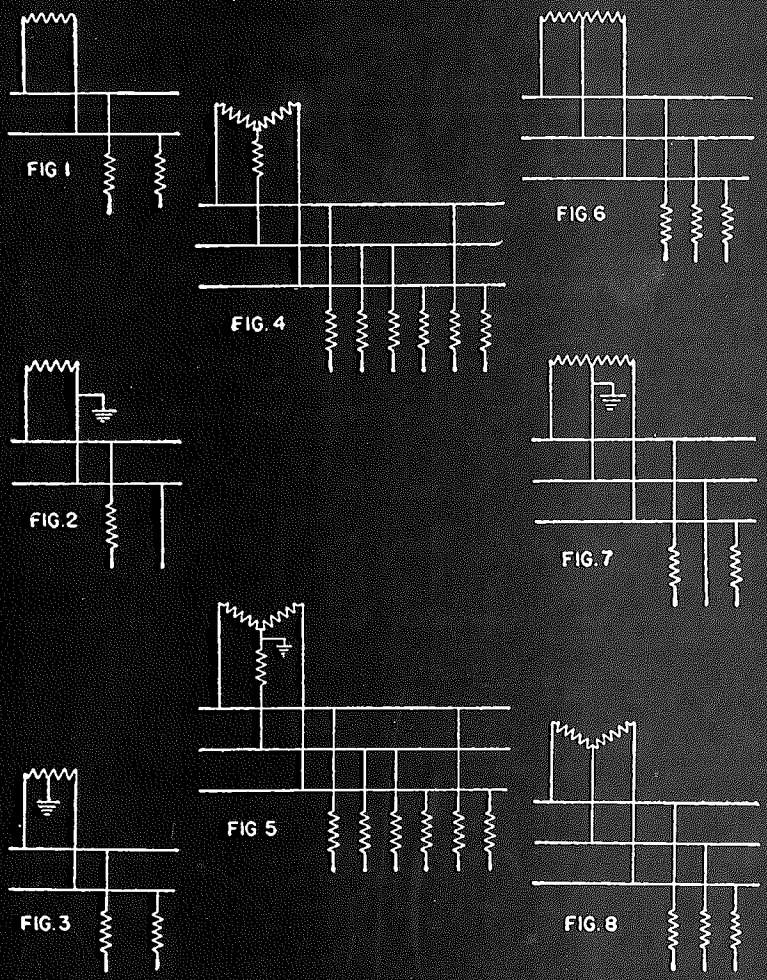
Supplementary overcurrent protective devices are not required to be interchangeable with branch circuit overcurrent protective devices.

E-240.35. Rating.

Supplementary overcurrent protective devices shall be rated at not more than 15 amperes.

Diagrams ~~240-29~~ E-240.29

Diagrams 1 to 19 showing Number of Overcurrent Units such as Trip Coils or Relays for the Protection of Circuits as required by Table ~~240-28.~~ E-240.28.



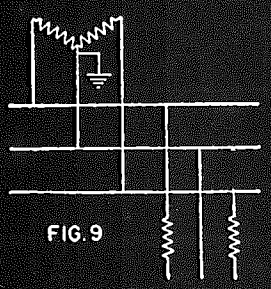


FIG. 9

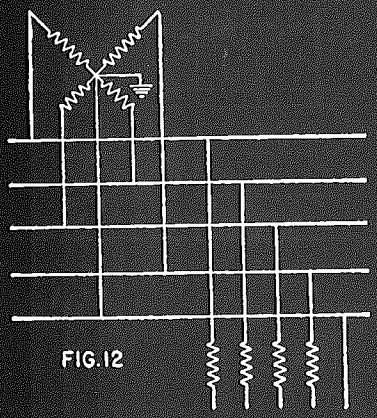


FIG. 12

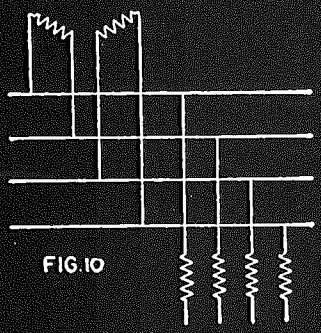


FIG. 10

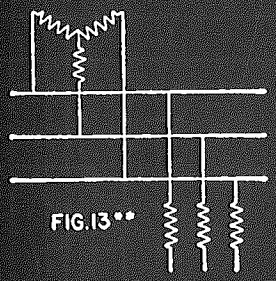


FIG. 13**

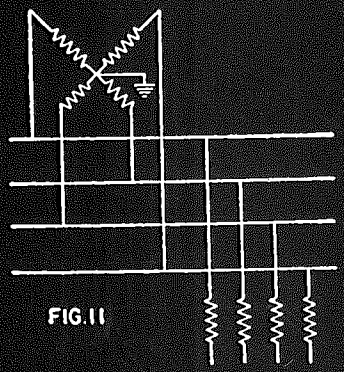


FIG. 11

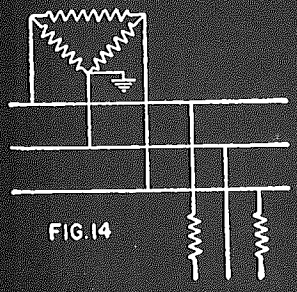


FIG. 14

**See Note 2 of Table ~~240-28.~~ E-240.28.

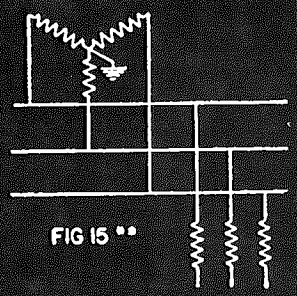


FIG 15 **

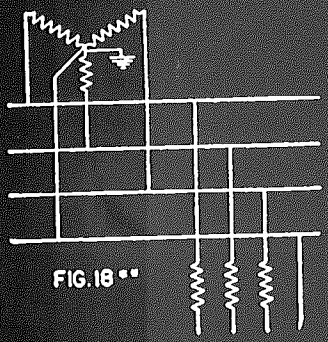


FIG. 18 **

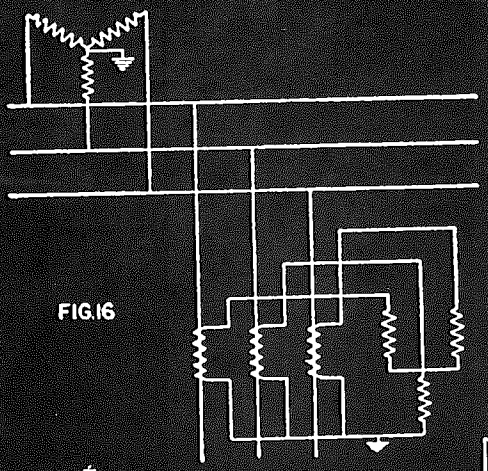


FIG. 16

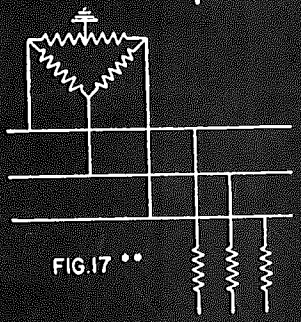


FIG. 17 **

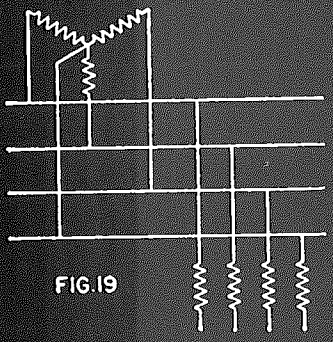


FIG. 19

**See Note 2 of Table ~~240-28.~~ E-240.28.

CHAPTER E-250

GROUNDING

A. General

E-250.001. Scope.

This Chapter treats of protection of electric installations by grounding. Insulation, isolation, and guarding are suitable alternatives under certain conditions. See E-195.16.

(1) Systems and Circuits. Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

(2) Exposed Conductor Enclosures. Exposed conductive materials enclosing electric conductors are grounded for the purpose of preventing a potential above ground on the enclosures.

(3) Exposed Equipment Enclosures. Exposed conductive materials enclosing electric equipment, or forming a part of such equipment, are grounded for the purpose of preventing a potential above ground on the equipment.

E-250.002. Other Chapters.

In other Chapters, applying to particular cases of installation of conductors and equipment, there are requirements that are in addition to those of this Chapter or are modifications of them:

	Chapters
Appliances	E-422
Cranes and Hoists	E-610
Elevators	E-620
Hazardous Locations	E-500-E-517
Inductive and Dielectric Heat Generating	E-665
Less Than 50 V	E-720
Lighting Fixtures	E-410
Motion Picture Studios	E-530
Motors and Controllers	E-430

	Chapters
Organs	E-650
Radio and Television	E-810
Services	E-230
Signs and Outline Lighting	E-600
Sound Recording, etc.	E-640
X-ray Equipment	E-660

B. Circuit and System Grounding

E-250.003. Two-Wire Direct-Current Systems.

Two-wire direct-current systems supplying interior wiring, and operating at not more than 300 volts between conductors, shall be grounded, unless such system is used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector.

Note: It is recommended that 2-wire direct-current systems operating at more than 300 volts between conductors be grounded when a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. It is recommended that 2-wire direct-current systems be not grounded when the voltage to ground of either conductor would exceed 300 volts after grounding. See E-250.022.

E-250.004. Three-Wire Direct-Current Systems.

The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded. See E-250.022

E-250.005. Alternating-Current Systems.

Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, except those covered in E-250.006, E-250.007 and E-250.008, shall be grounded when they can be so grounded that the maximum voltage to ground does not exceed 300 volts. Where a service conductor is uninsulated in accordance with E-230.004, the system shall be grounded.

Note 1. Higher voltage systems may be grounded.

Note 2. It is recommended that ungrounded systems supplying industrial equipment and operating at more than 150 volts and less than 600 volts be equipped with ground detectors.

E-250.006. Furnace Circuits.

Electric furnace circuits need not be grounded.

E-250.007. Electric Crane Circuits.

Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See E-503.13.

E-250.008. Circuits of Less Than 50 Volts.

Circuits of less than 50 volts need not be grounded, except as follows:

(1) Where supplied by transformers from systems of more than 150 volts to ground, except as provided in E-250.045(4).

(2) Where supplied by transformers from ungrounded systems.

(3) Where run overhead outside buildings.

C. Location of Grounding Connections

E-250.021. Current Over Grounding Conductors.

The grounding of wiring systems, circuits, arresters, cable armor, conduit, or other metal raceways as a protective measure shall be so arranged that there will be no objectionable passage of current over the grounding conductors. The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective functions, are not to be considered as objectionable. Where an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds, (1) one or more of such grounds shall be abandoned, or (2) their location shall be changed, or (3) the continuity of the conductor between the grounding connections shall be suitably interrupted, or (4) other means satisfactory to the administrative authority shall be taken to limit the current.

E-250.022. Grounding Connection for Direct-Current Systems.

Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services nor elsewhere on interior wiring.

E-250.023. Grounding Connections for Alternating-Current Systems.

Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each individual service, except as provided for in E-250.021. The connection shall be made on the supply side of the service disconnecting means. Each secondary distribution system which is grounded shall have at least one additional connection to a grounding electrode at the transformer or elsewhere. No connection to a grounding electrode shall be made to the grounded circuit conductor on the load side of the service disconnecting means, except as provided for in E-250.024.

E-250.024. Two or More Buildings Supplied by a Single Service.

(1) Where more than one building is supplied by the same service, the grounded circuit conductor of the wiring system of any building utilizing one branch circuit supplied from such service may be connected to a grounding electrode at such building, and in the case of any building housing equipment required to be grounded or utilizing two or more branch circuits supplied from such service, and in the case of a building housing live stock, shall be so connected.

(2) When a metal raceway system is used in any such building supplied from a single service and this metal raceway or any connected non-current carrying metal part is accessible from any grounded surface, the metal raceway system and the neutral conductor shall be bonded together and connected to an approved ground electrode at the entrance to the building.

E-250.025. Conductor to be Grounded.

For alternating-current interior wiring systems the conductor to be grounded shall be as follows:

(1) Single-phase, 2-wire: the identified conductor;

(2) Single-phase, 3-wire: the identified neutral conductor;

(3) Multi-phase systems having one wire common to all phases: the identified common conductor;

(4) Multi-phase systems having one phase grounded: the identified conductor;

(5) Multi-phase systems in which one phase is used as in (2): the identified neutral conductor. One phase only can be grounded.

See Chapter E-200.

Note: The identified conductor is commonly known as "the white wire."

E-250.026. Isolated Systems.

For an interior wiring system or circuit which is required to be grounded and which is not electrically connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard, on the supply side of the first switch controlling the system. See fine print note after E-200.03.

D. Enclosure Grounding

E-250.032. Service Conductor Enclosures.

Service raceways, service cable sheaths or armoring, when of metal, shall be grounded.

E-250.033. Other Conductor Enclosures.

Metal enclosures for conductors shall be grounded, except they need not be grounded in runs of less than 25 feet which are free from probable contact with ground, grounded metal, metal lath or conductive thermal insulation and which, where within reach from grounded surfaces, are guarded against contact by persons.

E-250.034. Spacing from Lightning Rods.

Metal enclosures of conductors shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together.

E. Equipment Grounding

E-250.042. Fixed Equipment - General.

Under any of the following conditions, exposed, non-current-carrying metal parts of fixed equipment, which are liable to become energized, shall be grounded:

(1) Where equipment is supplied by means of metal-clad wiring;

(2) Where equipment is located in a wet location and is not isolated;

(3) Where equipment is located within reach of a person who can make contact with any grounded surface or object;

(4) Where equipment is located within reach of a person standing on the ground;

(5) Where equipment is in a hazardous location; see Chapters E-500-E-517 inclusive;

(6) Where equipment is in electrical contact with metal or metal lath;

(7) Where equipment operates with any terminal at more than 150 volts to ground, except as follows:

(a) Enclosures for switches or circuit breakers where accessible to qualified persons only;

(b) Metal frames of electrically-heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground;

(c) Transformers mounted on wooden poles at a height of more than 8 feet from the ground.

Note: See E-103.04(2).

E-250.043. Fixed Equipment - Specific.

Exposed, non-current-carrying metal parts of the following kinds of equipment, regardless of voltage, shall be grounded:

(1) Frames of motors as specified in E-430.142;

(2) Controller cases for motors, except lined covers of snap switches;

(3) Electric equipment of elevators and cranes;

(4) Electric equipment in garages, theatres and motion picture studios, except pendent lampholders on circuits of not more than 150 volts to ground;

(5) Motion-picture projection equipment;

(6) Electric signs and associated equipment, unless these are inaccessible to unauthorized persons and are also insulated from ground and from other conductive objects;

(7) Generator and motor frames in an electrically operated organ, unless the generator is effectively insulated both from ground and from the motor driving it;

(8) Switchboard frames and structures supporting switching equipment, except that frames of direct-current, single-polarity switchboards need not be grounded where effectively insulated.

E-250.044. Non-Electrical Equipment.

The following metal parts shall be grounded:

(1) Frames and tracks of electrically operated cranes;

(2) The metal frame of a non-electrically driven elevator car to which electric conductors are attached.

(3) Hand-operated metal shifting ropes or cables of electric elevators;

(4) Metal enclosures such as partitions, grill work, etc., around equipment carrying voltages in excess of 750 volts between conductors, unless in substations or vaults under the sole control of the supply company.

E-250.045. Portable Equipment.

Under any of the following conditions, exposed non-current-carrying metal parts of portable equipment shall be grounded:

(1) In hazardous locations (see Chapters E-500 to E-517);

(2) When operated at more than 150 volts to ground, except:

(a) Motors, where guarded;

(b) Metal frames of electrically-heated appliances exempted by E-422.12.

(3) In residential occupancies, (a) clothes-washing, clothes-drying, and dish-washing machines, and (b) portable, hand held, motor operated tools and appliances of the following types: drills having a chuck capacity exceeding 1/8 inch, hedge clippers, lawn mowers, wet scrubbers, sanders and saws.

(4) In other than residential occupancies, (a) portable appliances used in damp or wet locations, or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers, and (b) portable tools which are likely to be used in wet and conductive locations shall be grounded except where supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

Note 1. This paragraph shall not be construed to prohibit the use of an insulating transformer with a secondary voltage greater than 50 volts, where the exposed metal parts of the appliance connected to such a transformer are grounded, and provided other conditions of this Chapter are fulfilled.

Note 2. It is recommended that the frames of all portable motors which operate at more than 50 volts and less than 150 volts to ground be grounded, where this can be readily accomplished.

E-250.046. Spacing from Lightning Rods.

Metal frames and enclosures of electric equipment shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together. See E-250.034 and E-250.086.

F. Methods of Grounding

E-250.051. Effective Grounding.

The path to ground from circuits, equipment, or conductor enclosures shall (1) be permanent and continuous and (2) shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and (3) shall have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuit.

E-250.052. Grounding a Circuit Conductor.

The grounding conductor may be connected to the grounded circuit conductor at any convenient point on the premises on the supply side of the service disconnecting means.

E-250.053. Common Grounding Conductor.

The grounding conductor for circuits may also be used for grounding equipment, conduit and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment.

E-250.054. Common Grounding Electrode.

Where the alternating-current system is connected to a grounding electrode in or at a building as specified in E-250.023 and E-250.024, the same electrode shall be used to ground conductor enclosures and equipment in or on that building.

E-250.055. Underground Service Cable.

Where served from a continuous underground metal-sheathed cable system, the sheath or armor of underground service cable metallically connected to the underground system, or underground service conduit containing a metal-sheathed cable bonded to the underground system, need not be grounded at the building and may be insulated from the interior conduit or piping.

E-250.056. Short Sections of Raceway.

Isolated sections of metal raceway or cable armor, where required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with E-250.057.

E-250.057. Fixed Equipment

(1) Metal boxes, cabinets and fittings, or non-current-carrying metal parts of other fixed equipment, where metallically connected to grounded cable armor or metal raceway, are considered to be grounded by such connection.

(2) Where not so connected they may be grounded in one of the following ways:

(a) By a grounding conductor run with circuit conductors; this conductor may be uninsulated, but where it is provided with an individual covering, the covering shall be finished to show a green color.

(b) By a separate grounding conductor installed the same as a grounding conductor for conduit and the like;

(c) By special permission, other means for grounding fixed equipment may be used.

E-250.058. Equipment on Structural Metal.

(1) Electric equipment secured to and in contact with the grounded structural metal frame of a building, shall be deemed to be grounded.

(2) Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded where the machine is grounded in accordance with this Code.

E-250.059. Portable Equipment.

Non-current-carrying metal parts of portable equipment may be grounded in any one of the following ways:

(1) By means of the metal enclosure of the conductors feeding such equipment, provided an approved plug is used, one fixed contacting member for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure is attached to the plug and to the equipment by connectors approved for the purpose;

(2) By means of a grounding conductor run with the circuit conductors in cable assemblies or flexible cords, provided an approved plug is used, one fixed contacting member for the purpose of connecting such grounding conductor to the grounded metal raceway or cable armor or to a grounding conductor installed only for equipment grounding purposes; the grounding conductor in a cable assembly may be uninsulated; but where an individual covering is provided for such conductors it shall be finished to show a green color;

(3) By means of a separate flexible wire or strap, insulated or bare, protected as well as practicable against physical damage. (This construction to be used only by special permission except where a part of an approved portable equipment.)

E-250.060. Frames of Electric Ranges and Electric Clothes Dryers.

Frames of electric ranges and electric clothes dryers shall be grounded by any of the means provided for in E-250.057 and E-250.059 or where served by 120-

240 volt, three-wire branch circuits, they may be grounded by connection to the grounded circuit conductors, provided the grounded circuit conductors are not smaller than No. 10 AWG. The frames of wall-mounted ovens and counter-mounted cooking units shall be grounded and may be grounded in the same manner as electric ranges.

E-250.061. Grounding Equipment to Circuit Conductor.

The grounded service conductor on the supply side of the service disconnecting means may be used for grounding meter housing and service equipment. The grounded circuit conductor on the load side of the service disconnecting means shall not be used for grounding equipment, cable armor, or metal raceways except as provided in E-250.057(2)(c) and in E-250.060.

G. Bonding

E-250.071. Bonding at Service Equipment.

The electrical continuity of the grounding circuit for the following equipment and enclosures shall be assured by one of the means given in E-250.072.

(1) The service raceways or service cable armor or sheath, except as provided in E-230.063(2) and E-250.055;

(2) All service equipment enclosures containing service entrance conductors, including meter fittings, boxes or the like, interposed in the service raceway or armor;

(3) Any conduit or armor which forms part of the grounding conductor to the service raceway.

E-250.072. Continuity at Service Equipment.

Electrical continuity at service equipment shall be assured by one of the following means:

(1) Bonding equipment to the grounded service conductor in a manner provided in E-250.113.

(2) Threaded couplings and threaded bosses on enclosures with joints made

up tight where rigid conduit is involved.

(3) Threadless couplings made up tight for rigid conduit and electrical metallic tubing.

(4) Bonding jumpers meeting the other requirements of this chapter. Bonding jumpers shall be used around concentric or eccentric knockouts which are punched or otherwise formed so as to impair the electrical connection to ground.

(5) Other devices (not locknuts and bushings) approved for the purpose.

E-250.073. Metal Armor or Tape of Service Cable.

With service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armor or tape, the metal covering is considered to be adequately grounded.

E-250.074. Continuity at Other Enclosures.

The electrical continuity of metallic raceway systems and cable armor that are to serve as grounding conductors shall be assured. At points where raceway or armor connects to metal enclosures, any non-conducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary.

E-250.075. Voltages Exceeding 250 Volts.

The electrical continuity of metal raceway or metal sheathed cable which contains any conductor other than service entrance conductors of more than 250 volts to ground shall be assured by one of the methods specified in E-250.072(2) - (5), or by one of the following methods:

(1) Threadless fittings, made up tight, with conduit or armored cable;

(2) Two locknuts, one inside and one outside of boxes and cabinets.

E-250.076. Loosely-Jointed Metal Raceways.

Expansion joints and telescoping sections of raceways shall be made electrically continuous by bonding jumpers or other approved means. Metal trough raceways used in connection with sound recording and reproducing, made up in sections, shall

contain a grounding conductor to which each section shall be bonded.

E-250.077. Hazardous Locations.

In hazardous locations, regardless of the voltage involved, the electrical continuity of metallic raceway, boxes and the like, shall be assured by one of the methods specified in E-250.072(2-5).

E-250.078. Bonding Jumpers.

Bonding jumpers shall conform to the following:

(1) Material and Size. Bonding jumpers shall be of copper or other corrosion-resistant material and shall be of sufficient size to have current-carrying capacity not less than is required for the corresponding grounding conductor;

(2) Attachment. Bonding jumpers shall be attached to cabinets and the like in a manner provided in E-250.113; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in E-250.114.

H. Grounding Electrodes

E-250.081. Water Pipe.

A metallic underground water piping system, either local or supplying a community, shall always be used as the grounding electrode where such a piping system is available. If the buried portion of the metallic piping system is less than 50 feet excluding well casings, or has a resistance to ground of more than 3 ohms, the piping system ground shall be augmented by at least 2 grounding electrodes recognized in E-250.082 and E-250.083 wherever the circuit or non-current carrying parts are required to be grounded.

E-250.082. Other Available Electrodes.

Where a water system as described in E-250.081 is not available, the grounding connection may be made to any of the following if the resistance to ground is less than 3 ohms or the metal is supplemented by two electrodes of the type recognized in E-250.083:

(1) The metal frame of the building, if effectively grounded;

(2) A continuous metallic underground gas piping system;

(3) Other local metallic underground systems, such as piping, tanks, and the like.

E-250.083. Made Electrodes.

Where electrodes described in E-250.081 and E-250.082 are not available, the grounding electrode shall consist of a driven pipe, driven rod, buried plate or other device approved for the purpose and conforming to the following requirements:

(1) Plate Electrodes. Each plate electrode shall present not less than 2 square feet of surface to exterior soil. Electrodes of iron, or steel plates shall be at least $\frac{1}{4}$ inch in thickness. Electrodes of non-ferrous metal shall be at least 0.06 inch in thickness.

(2) Pipe Electrodes. Electrodes of pipe or conduit shall be not smaller than of the 3/4 inch trade size and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(3) Rod Electrodes. Electrodes of rods of steel or iron shall be at least 5/8 inch in diameter. Approved rods of non-ferrous materials or their approved equivalent used for electrodes shall be not less than $\frac{1}{2}$ inch in diameter.

(4) Installation. Electrodes should, as far as practicable, be imbedded below permanent moisture level. Except where rock bottom is encountered, pipes or rods shall be driven to a depth of at least 8 feet regardless of size or number of electrodes used. Pipes or rods when less than standard commercial length shall preferably be of one piece. Such pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel or other poorly conducting materials. Where rock bottom is encountered at a depth of less than 4 feet, electrodes shall be buried in a horizontal trench, and where pipes or rods are used as the electrode they shall comply with E-250.083(2) and (3) and shall not be less than 8 feet in length. Each electrode shall be separated at least 6 feet from any other electrode, including those used for signal circuits, radio, lightning rods, or any other purpose.

E-250.084. Resistance.

If the resistance to ground of an underground piping or metallic system is more than 3 ohms, two made electrodes must be added to the grounding electrodes. If a single made electrode does not have a resistance to ground of less than 25 ohms, two made electrodes shall be installed. The distance between made electrodes shall be at least 6 feet.

E-250.085. Railway Tracks.

Rails or other grounded conductors of electric railway circuits shall not be used (1) as a ground for other than railway lightning arresters and railway equipment, conduit, armored cable, metal raceway, and the like, where other effective grounds are available; and (2) in no case shall such rails or other grounded conductors of railway circuits be used for grounding interior wiring systems other than those supplied from the railway circuit itself.

E-250.086. Use of Lightning Rods.

Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes required by this chapter for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. See E-800.31(2)(e).

J. Grounding Conductors

E-250.091. Material.

The material for the grounding conductors shall be as follows:

(1) For System or Common Grounding Conductor. The grounding conductor of a wiring system shall be of copper or other corrosion-resistant material. The conductor may be solid or stranded, insulated or bare. Except in cases of bus-bars, the grounding conductor shall be without joint or splice throughout its length. Where the grounding conductor is not of copper, its electrical resistance per linear foot

shall not exceed, and its tensile strength shall not be less than that of the copper allowable/conductor for such a purpose.

(2) For Conductor Enclosures and Equipment Only. The grounding conductor for equipment and for conduit and other metal raceways or enclosures for conductors, may be a conductor of copper or other corrosion-resistant material, stranded or solid, insulated or bare, a bus-bar or a rigid conduit, steel pipe, electrical metallic tubing or the armor of armored cable, except that under conditions favorable to corrosion a grounding conductor of copper or other corrosion-resistant material shall be used.

E-250.092. Installation.

Grounding conductors shall be installed as follows:

(1) System or Common Grounding Conductor. A grounding conductor, No. 4 or larger, may be attached to the surface on which it is carried without the use of knobs, tubes or insulators. It need not have protection unless exposed to severe physical damage. A No. 6 grounding conductor, which is free from exposure to physical damage, may be run along the surface of the building construction without metal covering or protection, where it is rigidly stapled to the construction; otherwise, it shall be in conduit, electrical metallic tubing or cable armor. Grounding conductors smaller than No. 6 shall be in conduit, electrical metallic tubing or cable armor. Metallic enclosures for grounding conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Where rigid metallic conduit or steel pipe is used as protection for a grounding conductor, the installation shall comply with the requirements of Chapter E-346; where electrical metallic tubing is used, the installation shall comply with the requirements of Chapter E-348.

(2) Conductor Enclosures and Equipment Only. A grounding conductor for conductor enclosures and equipment only shall meet the requirements of E-250.092(1), except that where smaller than No. 6 , as permitted by E-250.095, it need not

be armored or installed in a raceway where run through the hollow spaces of a wall or partition or otherwise run so as to be not subject to physical damage.

E-250.093. Direct-Current Circuits.

The carrying capacity of the grounding conductor for a direct-current supply system or generator shall be not less than that of the largest conductor supplied by the system, except that where the grounded circuit conductor is a neutral derived from a balancer winding or a balancer set protected in accordance with requirements of E-445.04(4), the size of the grounding conductor shall not be less than that of the neutral conductor. The grounding conductor shall in no case be smaller than No. 8 copper.

E-250.094. Alternating-Current and Service Equipment.

(1) Wiring System and Common Grounding Conductor. The size of the grounding conductor for an alternating current system or for a common grounding conductor shall not be less than is given in Table E-250.094(1), except that where connected to made electrodes (as in E-250.083) the conductor need not be larger than No. 6 copper wire or its equivalent in carrying capacity.

(2) Where the wiring system is not grounded at the premises, the size of a grounding conductor for a service raceway, for the metal sheath or armor of a service cable, and for service equipment shall be not less than is given in Table E-250.094(2), except that where connected to made electrodes (as in E-250.083) the conductor need not be larger than No. 6 copper or its equivalent in carrying capacity.

Table E-250.094(1). Sizes of Grounding Conductors

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Copper Grounding Conductor AWG. No.
2 or smaller	8
1 or 0	6
00 or 000	4
Over 000 to 350,000 c.m.	2
Over 350,000 c.m. to 600,000 c.m.	0
Over 600,000 c.m. to 1,100,000 c.m.	00
Over 1,100,000 c.m.	000

Table E-250.094(2). Sizes of Grounding Conductors

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Grounding Conductor		
	Copper Wire AWG. No.	Conduit or Pipe Trade Size (Inch)	Electrical Metallic Tubing Trade Size (Inch)
2 or smaller	8	$\frac{1}{2}$	$\frac{1}{2}$
1 or 0	6	$\frac{1}{2}$	1
00 or 000	4	3/4	$1\frac{1}{4}$
Over 000 to 350,000 c.m.	2	3/4	$1\frac{1}{4}$
Over 350,000 c.m. to 600,000 c.m.	0	1	2
Over 600, 000 c.m. to 1,100,000 c.m.	00	1	2
Over 1,100,000 c.m.	000	1	2

E-250.095. Interior Raceway and Equipment.

The size of the grounding conductor for conduit, cable sheath or armor, and other metal raceways or enclosures for conductors, and for equipment, shall be not less than given in Table E-250.095, except that where connected to electrodes as described in E-250.083, the grounding conductor need not be larger than No. 6 copper or its equivalent.

E-250.096. Portable and Pendent Equipment.

For grounding portable or pendent equipment, the conductors of which are

protected by fuses or circuit-breakers rated or set at not exceeding 20 amperes, No. 18 copper wire may be used. Conductors of Nos. 16 or 18 copper which are used for grounding portable equipment shall be part of an approved flexible cord assembly. For grounding portable or pendent equipment protected at more than 20 amperes, Table E-250.095 shall be followed.

Table E-250.095. Sizes of Grounding Conductors

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size of Grounding Conductor		
	Copper Wire No.	Conduit or Pipe (Inch)	Electrical Metallic Tubing (Inch)
20	16*	$\frac{1}{2}$	$\frac{1}{2}$
30	14	$\frac{1}{2}$	$\frac{1}{2}$
40	12	$\frac{1}{2}$	$\frac{1}{2}$
60	10	$\frac{1}{2}$	$\frac{1}{2}$
100	8	$\frac{1}{2}$	$\frac{1}{2}$
200	6	$\frac{1}{2}$	1
400	4	3/4	$1\frac{1}{4}$
600	2	3/4	$1\frac{1}{4}$
800	0	1	2
1000	00	1	2
1200	000	1	2

*Permissible only when part of an approved cable assembly.

E-250.097. Outline Lighting.

Isolated non-current-carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from physical damage, where a conductor complying with E-250.095 is used to ground the group.

E-250.098. Common Raceway.

A grounding conductor may be run in the same metal raceway with other conductors of the system to which it is connected.

E-250.099. Continuity.

No automatic cutout or switch shall be placed in the grounding conductor of an interior wiring system unless the opening of the cutout or switch disconnects all sources of energy.

K. Grounding Conductor Connections

E-250.111. To Raceway or Cable Armor.

The point of connection of the grounding conductor to interior metal raceways, cable armor and the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in E-250.095.

E-250.112. To Electrode.

The grounding connection to the electrode shall be located as follows:

(1) To Water Pipes. System or common grounding conductors shall be attached to a water piping system on the street side of the water meter or on a cold water pipe of adequate current-carrying capacity as near as practicable to the water service entrance to the building. Where the source of the water supply is from a driven well in the basement of the premises, the connection shall be made as near as practicable to the well. Where practicable, the point of attachment shall be accessible. Where the point of attachment is not on the street side of the water meter, the water piping system shall be made electrically continuous by bonding together all parts between the attachment and the street side of the water meter or the pipe entrance which contain insulating sections or are liable to become disconnected, as at meters, valves and service unions. Equipment may be grounded to a cold water pipe near the equipment.

(2) To Gas Pipes. The point of attachment of a grounding conductor to gas piping shall always be on the street side of the gas meter, and shall be accessible where practicable.

(3) To Other Electrodes. The grounding conductor shall be attached to other electrodes permitted in E-250.082 and E-250.083 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

E-250.113. Attachment to Circuits and Equipment.

The grounding conductor, bond, or bonding jumper shall be attached to circuits,

conduits, cabinets, equipment, and the like, which are to be grounded, by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used.

E-250.114. Attachment to Electrodes.

The grounding conductor shall be attached to the grounding electrode by means of (1) an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron, or (2) a pipe fitting, plug, or other approved device, screwed into the pipe or into the fitting, or (3) other equally substantial approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting, unless the clamp or fitting is of a type approved for such use.

E-250.115. Ground Clamps.

For the grounding conductor of a wiring system the sheet-metal-strap type of ground clamp is not considered adequate unless the strap is attached to a rigid metal base which, when installed, is seated on the water pipe, or other electrode and the strap is of such material and dimensions that it is not liable to stretch during or after installation.

Note: Ground clamps for use on copper water tubing and copper, brass, or lead pipe should preferably be of copper , and those for use on galvanized or iron pipe should preferably be of galvanized iron and so designed as to avoid physical damage to pipe.

E-250.116. Protection of Attachment.

Ground clamps or other fittings, unless approved for general use without protection, shall be protected from ordinary physical damage (1) by being placed where they are not liable to be damaged or (2) by being enclosed in metal, wood, or equivalent protective covering.

E-250.117. Clean Surfaces.

Where a non-conductive protective coating, such as paint or enamel, is used on the equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good electrical connection.

L. Instrument Transformers, Relays, etc.

E-250.121. Instrument Transformer Circuits.

The secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground, and, where on switchboards, shall be grounded irrespective of voltage, except that such circuits need not be grounded where the primary windings are connected to circuits of 750 volts or less and no live parts or wiring are exposed or accessible to other than qualified persons.

E-250.122. Instrument Transformer Cases.

Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons, except that cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters, need not be grounded.

E-250.123. Cases of Instruments, Meters and Relays - Operating Voltage 750 or Less.

Instruments, meters and relays which operate with windings or working parts at 750 volts or less shall be grounded as follows:

(1) Not on Switchboards. Instruments, meters and relays not located on switchboards, which operate with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts grounded;

(2) On Dead Front Switchboards. Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having no live parts on the front of the panels shall have the cases grounded;

(3) On Live Front Switchboards. Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases grounded. Mats of insulating rubber or other suitable floor insulation, shall be provided for the operator where the voltage to ground exceeds 150.

E-250.124. Cases of Instruments, Meters and Relays - Operating Voltage over 750.

Where instruments, meters and relays have current-carrying parts over 750 volts to ground, they shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or guards. Their cases shall not be grounded, except as follows:

(1) In electrostatic ground detectors the internal ground segments of the instrument are connected to the instrument case and grounded; the ground detector shall be isolated by elevation.

E-250.125. Instrument Grounding Conductor.

The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12, where of copper or where of other metal, shall have equal conductance. Cases of instrument transformers, instruments, meters and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

M. Lightning Arresters

E-250.131. On Secondary Services, 750 Volts or Less.

Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor. The bonding or grounding conductor shall be of copper not smaller than

No. 14 or of equivalent corrosion-resistant material.

E-250.132. On Primary Circuits.

The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected as follows:

(1) Metallic Interconnection. A metallic interconnection may be made to the secondary neutral provided that, in addition to the direct grounding connection at the arrester:

(a) The grounded conductor of the secondary has elsewhere a grounding connection to a continuous metallic underground water piping system. However, in urban water pipe areas where there are at least four waterpipe connections on the neutral and not less than four such connections in each mile of neutral, the metallic interconnection may be made to the secondary neutral with omission of the direct grounding connection at the arrester.

(b) The grounded conductor of the secondary system is part of a multi-grounded neutral system, of which the primary neutral has at least four ground connections in each mile of line in addition to a ground at each service.

(2) Through Spark Gap. Where the secondary is not grounded as in E-250.132(1), but is otherwise grounded as in E-250.082 and E-250.083, such interconnection, where made, shall be through a spark gap having a 60-cycle breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kv, and there shall be at least one other ground on the grounded conductor of the secondary not less than 20 feet distant from the lightning arrester grounding electrode.

(3) By Special Permission. Except as above provided, interconnection of the arrester ground and the secondary neutral may be made only by special permission.

CHAPTER E-280

LIGHTNING ARRESTERS

A. Industrial Stations

E-280.01. Where Required.

Lightning arresters shall be provided in industrial stations in locations where thunderstorms are frequent and adequate protection against lightning is not otherwise provided.

Note: For lightning arresters in hazardous locations, see Chapters E-500 - E-517.

E-280.02. Number Required.

A lightning arrester shall be connected to each ungrounded overhead conductor entering or leaving the station, except that where there is more than one circuit, a single set of arresters may be installed on the station bus where means are provided to protect circuits that may remain disconnected from the bus.

E-280.03. Where Connected.

The arrester shall be connected on the line side of all connected station apparatus.

B. Other Occupancies

E-280.11. Utilization Equipment.

Lightning arresters installed for the protection of utilization equipment may be installed either inside or outside the building or enclosure containing the equipment to be protected. Arresters, unless isolated by elevation or made otherwise inaccessible to unqualified persons, shall be enclosed, and where the operating voltage of the circuit exceeds 750 volts between conductors they shall be inaccessible to unqualified persons.

C. General

E-280.21. Location - Indoors.

Arresters installed indoors shall be located well away from other equipment, passageways and combustible parts of buildings, and where containing oil shall be separated from other equipment by walls meeting the requirements of E-450.42.

E-280.22. Location - Outdoors.

Where arresters containing oil are located outdoors, provision shall be made to drain away any accumulation of oil.

Note: Oil may be drained away by ditches and drains or the oil may be absorbed and danger of spreading removed by paving the yard with cinders or other absorbent material to a depth of several inches.

E-280.23. Connections - Size and Material.

The connections between the arrester and the line wire or bus, and between arrester and ground shall be of copper wire or cable or the equivalent, and, except as provided on secondary services in E-250.131, shall not be smaller than No. 6, and shall be made as short and as straight as practicable, avoiding as far as possible all bends and turns, especially sharp bends.

E-280.24. Insulation.

Lightning-protection accessories such as gap electrodes, and choke coils where used, shall have an insulation from ground or from other conductors at least equal to the insulation required at other points of the circuit.

E-280.25. Switch for Isolating Arrester.

Where isolating switches or disconnecting devices are used, they shall withstand, in full open position, a voltage test between live parts 10 per cent in excess of the maximum voltage test they will withstand to ground.

E-280.26. Grounding

Lightning arresters shall be grounded in the manner prescribed in Chapter E-250.