Communication Systems

CHAPTER E-800

COMMUNICATION CIRCUITS

A. General

E-800.01. Scope.

The provisions of this chapter shall apply to telephone, telegraph (except radio), district messenger, fire and burglar alarms and similar central station systems and to telephone systems not connected to a central station system but using similar type of equipment, methods of installation and maintenance.

Note 1. Such protective measures as are essential to safeguard these systems under the various conditions to which they are subjected are outlined in these rules.

Note 2. For detailed service requirements for fire alarm, sprinkler supervisory or watchman systems, see the Standards of the National Fire Protection Association.*

B. Protection

E-800.02. Protective Devices.

A protector approved for the purpose shall be provided on each circuit, aerial or underground, so located within the block containing the building served as to be liable to accidental contact with light or power conductors operating at a potential exceeding 300 volts, and on each circuit run partly or entirely in aerial wire or cable not confined within a block.

Note: The word "block" as used in this chapter shall be construed to mean a square or portion of a city, town, or village enclosed by streets and including the alleys so enclosed but not any street.

(1) Location. The protector shall be located in or on the building as near as practicable to the point where the conductors enter. In the case of an underground entrance the protector may be located at the junction of the underground and the aerial wires.

*The NFPA standards on fire alarm and supervisory systems are published by the

NFPA in the National Fire Codes, Vol. V and in separate pamphlet form by the NFPA Nos. 71, 72 and 73).

(2) Hazardous Locations. The protector shall not be located in any hazardous location as defined in Chapter E-500, nor in the vicinity of easily ignitible material.

(3) Protector Requirements. The protector shall be mounted on a noncombustible, nonabsorptive insulating base and shall consist of an arrester between each line conductor and the ground, and a fuse in each line conductor, the fuses protecting the arrester except as specified in E-800.02(4). The protector terminals shall be plainly marked to indicate line, instrument and ground.

(4) Omission of Fuses. A protector without fuses may be used under any of the following conditions:

(a) Where circuits enter a building through metal-sheathed cable, provided the metal sheath of the cable is effectively grounded and the conductors in the cable are not larger than No. 24 gauge copper.

(b) Where insulated conductors, in accordance with E-800.11(3)(a) and (b) are used to extend circuits to a building from a metal-sheathed cable or from a nonmetallic-sheathed cable having a metal grounding shield between the sheath and the conductor assembly, provided the metal sheath or the metal shield is effectively grounded and the conductors in the cable or cable stub are not larger than No. 24 gauge copper.

(c) Where insulated conductors, in accordance with E-800.11(3)(a) and (b) are used to extend circuits to a building from other than grounded metal-sheathed cable, provided 1. the protector is approved for this purpose and 2. the protector grounding conductor is connected to a water pipe electrode or the grounding conductor or grounding electrode of a multi-grounded neutral power system and 3. the connections of the insulated conductors to the exposed plant or the conductors of the exposed plant shall safely fuse at currents less than the current-carrying capacity of the protector used.

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

E-800.03. Installation of Conductors.

Conductors from the protector to the equipment or, where no protector is required, conductors attached to the outside of, or inside the building shall comply with the following:

(1) Separation from Other Conductors. Conductors shall be separated from conductors of electric light and power circuits as follows:

(a) Open Conductors. Conductors shall be separated at least 2 inches from any light or power conductors not in metallic raceways or metal-sheathed cable unless permanently separated from the conductors of the other system by a continuous and firmly fixed non-conductor, additional to the insulation on the wire, such as porcelain tubes or flexible tubing.

(b) In Raceways and Boxes. Communication conductors shall not be placed in any raceway, compartment, outlet box, junction box or similar fitting with conductors for light and power circuits or Class 1 signal and control circuits unless the conductors of the different systems are separated by a partition; provided that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where such conductors are introduced solely for power supply to communication equipment or for connection to remote-control equipment.

(c) In Shafts. Conductors may be run in the same shaft with conductors for light and power provided the conductors of the two systems are separated at least 2 inches, or where the conductors of either system are encased in noncombustible tubing.

(2) Vertical Runs. Conductors bunched together in a vertical run in a shaft shall have a fire-resistant covering capable of preventing the carrying of fire from floor to floor, except where conductors are encased in noncombustible tubing or are

located in a fireproof shaft having fire stops at each floor.

Note: The conductors referred to in this rule would ordinarily be insulated but the kind of insulation is not specified as reliance is placed on the protective device to stop all dangerous voltages and currents.

C. Outside Conductors

E-800.11. Overhead Conductors.

Overhead conductors entering buildings shall comply with the following:

(1) On Poles. Where communication conductors and light or power conductors are supported by the same pole, the following conditions shall be met:

(a) Relative Location. The conductors should preferably be located below the light or power conductors.

(b) Attachment to Crossarms. Conductors shall not be attached to a crossarm which carries light or power conductors.

(c) Climbing Space. The climbing space through signal conductors shall comply with the requirements of E-730.14.

(2) On Roofs. Conductors passing over buildings shall be kept at least 8 feet above any roof having a pitch of 3" or less per foot except small auxiliary buildings such as garages and the like.

(3) Circuits Requiring Protectors. Circuits which require protectors (see E-800.02) shall comply with the following:

(a) Insulation, Single or Paired Conductors. Each conductor, from the last outdoor support to the protector, shall have 1/32-inch rubber insulation, except that when such conductors are entirely within a block the insulation on the conductor may be less than 1/32-inch, but not less than 1/40-inch in thickness. In addition, the conductor, either individually or over the pair, shall be covered with a substantial fibrous covering or equivalent protection. Conductors approved for the purpose having rubber insulation of a thickness less than specified above, or having other kinds of insulation may be used.

(b) Insulation, Cables. Conductors within a cable of the metal-sheathed type, or within a cable having a rubber sheath of at least 1/32-inch thickness and covered with a substantial fibrous covering, may have paper or other suitable insulation. Where the metal or rubber sheath is omitted, each conductor shall be insulated as required in E-800.11(3)(a), and the bunched conductors shall be covered with a substantial fibrous covering or equivalent covering.

(c) On Buildings. Open conductors shall be separated at least 4 inches from light or power conductors not in conduit or cable, unless permanently separated from conductors of the other system by a continuous and firmly fixed non-conductor additional to the insulation on the wires, such as porcelain tubes or flexible tubing. Open conductors exposed to accidental contact with light and power conductors operating at over 300 volts, and attached to buildings, shall be separated from woodwork by being supported on glass, porcelain or other insulating material approved for the purpose except that such separation is not required where fuses are omitted, as provided for in E-800.02(4), or where conductors approved for the purpose are used to extend circuits to a building from a cable having a grounded metal sheath.

(d) Entering Buildings. Where a protector is installed inside the building, the conductors shall enter the building either through a noncombustible, nonabsorptive insulating bushing, or through a metal raceway. The insulating bushing may be omitted where the entering conductors 1. are in metal-sheathed cable, 2. pass through masonry, 3. are approved for the purpose and fuses are omitted as provided for in E-800.02(4), or 4. are approved for the purpose and are used to extend circuits to a building from a cable having a grounded metal sheath. Raceways or bushings shall slope upward from the outside or, where this cannot be done, drip loops shall be formed in the conductors immediately before they enter the building. Raceways shall be equipped with an approved service head. More than one conductor may enter through a single raceway or bushing. Conduits or other metallic raceways located ahead of the protector shall be grounded.

E-800.12. Lightning Conductors.

Where practicable, a separation of at least six feet shall be maintained between open conductors of communication systems on buildings and lightning conductors.

D. Underground Circuits

E-800.21. Underground Circuits.

Underground conductors of communication circuits entering buildings shall comply with the following:

(1) With Electric Light or Power Conductors. Underground conductors in a duct, handhole, or manhole containing electric light or power conductors, shall be in a section separated from such conductors by means of brick, concrete, or tile partitions.

(2) Underground Block Distribution. Where the entire street circuit is run underground and the circuit within the block is so placed as to be free from liability of accidental contact with electric light or power circuits of over 300 volts, the insulation requirements of E-800.11(3)(a) and E-800.11(3)(d) shall not apply, the conductors need not be placed on insulating supports and no bushings shall be required where the conductors enter the building.

E. Grounding

E-800.31. Grounding.

Equipment shall be grounded as follows:

(1) Cable Sheath. The metal sheath of aerial cables entering buildings which are liable to contact with electric light or power conductors shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device.

(2) Protector Ground. The protector ground shall comply with the following:

(a) Insulation. The grounding conductor shall have a 1/32-inch rubber insulation and shall be covered by a substantial fibrous covering. Conductors approved for the purpose having less than 1/32-inch rubber insulation or having other kinds of insulation may be used.

(b) Size. The grounding conductor shall not be smaller than No. 18 copper.

(c) Run in Straight Line. The grounding conductor shall be run in as straight a line as practicable to the grounding electrode.

(d) Physical Damage. Where necessary, the grounding conductor shall be guarded from physical damage.

(e) Electrode. The grounding conductor shall preferably be connected to a water pipe electrode. Where a water pipe is not readily available and the grounded conductor of the power service is connected to the water pipe at the building, the protector grounding conductor may be connected to the power service conduit, service equipment enclosures, or grounding conductor of the power service. In the absence of a water pipe, connection may be made to a continuous and extensive underground gas piping system, to an effectively grounded metallic structure, or to a ground rod or pipe driven into permanently damp earth. Steam or hot water pipes, or lightning rod conductors shall not be employed as electrodes for protectors. A driven rod or pipe used for grounding power circuits shall not be used for grounding communication circuits unless the driven rod or pipe is connected to the grounded conductor of a multi-grounded neutral power system. The requirements for separate made electrodes for power and lighting system grounds, those for communication systems, and those for a lightning rod installation shall not prohibit the bonding together of all such made electrodes. (See E-250.086.)

(f) Electrode Connection. The grounding conductor shall be attached to a pipe electrode by means of a bolted clamp to which the conductor is soldered or otherwise connected in an effective manner. Where a gas pipe electrode is used, connection shall be made between the gas meter and the street main. In every case the connection to the grounding electrode shall be made as close to the earth as practicable.

CHAPTER E-810

RADIO AND TELEVISION EQUIPMENT

A. General

E-810.01. Scope.

This chapter shall apply to radio and television receiving equipment and to amateur radio transmitting and receiving equipment, but shall not apply to equipment and antennas used for coupling carrier current to power line conductors.

Note: It is recommended that the administrative authority be freely consulted as to the specific methods to be followed in any case of doubt relative to installation of antenna and counterpoise conductors and that the National Electrical Safety Code, Part 5, be followed.

E-810.02. Application of Other Chapters.

Wiring from the source of power to and between devices connected to the interior wiring system shall comply with Chapters E-100 to E-400, inclusive, except as modified by E-640.03, E-640.04 and E-640.05. Wiring for radio-frequency and audio-frequency equipment and loud speakers shall comply with Chapter E-640.

E-810.03. Community Television Antenna.

The antenna shall comply with the requirements of this chapter. The distribution system shall comply with Chapter E-800.

E-810.04. Radio Noise Suppressors.

Radio interference eliminators, interference capacitors or radio noise suppressors connected to power supply leads shall be of a type approved for the purpose. They shall not be exposed to physical damage.

B. Receiving Equipment Only

Antenna Systems - General

E-810.11. Material.

Antenna, counter-poise and lead-in conductors shall be of hard-drawn copper, bronze, aluminum alloy, copper-clad steel or other high-strength, corrosion-resistant material. Soft-drawn or medium-drawn copper may be used for lead-in conductors where the maximum span between points of support is less than 35 feet.

E-810.12. Supports.

Outdoor antenna and counter-poise and lead-in conductors shall be securely supported. They shall not be attached to poles or similar structures carrying electric light or power wires or trolley wires of more than 250 volts between conductors. Insulators supporting the antenna or counter-poise conductors shall have sufficient mechanical strength to safely support the conductors. Lead-in conductors shall be securely attached to the antenna.

E-810.13. Avoidance of Contacts with Conductors of Other Systems.

Outdoor antenna, counter-poise and lead-in conductors from an antenna to a building shall not cross over electric light or power circuits and shall be kept well away from all such circuits so as to avoid the possibility of accidental contact. Where proximity to electric light and power service conductors of less than 250 volts between conductors cannot be avoided, the installation shall be such as to provide a clearance of at least two feet. It is recommended that antenna and counter-poise conductors be so installed as not to cross under electric light or power conductors.

E-810.14. Splices.

Splices and joints in antenna and counter-poise span shall be made with approved splicing devices or by such other means as will not appreciably weaken the conductors.

Note: Soldering may ordinarily be expected to weaken the conductor. Therefore, the joint should be mechanically secure before soldering.

E-810.15. Grounding.

Masts and metal structures supporting antennas shall be permanently and effectively grounded, without intervening splice or connection.

Antenna Systems - Receiving Station

E-810.16. Size of Wire-Strung Antenna and Counter-poise.

(1) Outdoor antenna and counter-poise conductors for receiving stations shall

be of a size not less than given in Table E-810.16(1).

(2) Self-Supporting Antennas. Outdoor antennas, such as vertical rods or dipole structures, shall be of noncorrodible materials and of strength suitable to withstand ice and wind loading conditions, and shall be located well away from overhead conductors of electric light and power circuits of over 150 volts to ground so as to avoid the possibility of the antenna or structure falling into or accidental contact with such circuits.

Table E-810.16(1)

Size of Receiving-Station Outdoor Antenna Conductors

Material	Minimum Size of Conductors — When Maximum Open Span Length is Less than 35 feet	35 feet to 150 feet	Over 150 feet
Aluminum alloy, hard-drawn copper	19	14	12
Copper-clad steel, bronze or other high strength material	20	17	14

Note: For very long span lengths larger conductors will be required, depending on the length of the span and the ice and wind loading.

E-810.17. Size of Lead-In.

Lead-in conductors from outside antenna, and counter-poise for receiving stations, shall, for various maximum open span lengths, be of such size as to have a tensile strength at least as great as that of the conductors for antenna as specified in E-810.16. Where the lead-in consists of two or more conductors which are twisted together or are enclosed in the same covering or are concentric, the conductor size shall, for various maximum open span lengths, be such that the tensile strength of the combination will be at least as great as that of the conductors for antenna as specified in E-810.16.

E-810.18. Clearances.

(1) On Buildings Outside. Lead-in conductors attached to buildings shall be so installed that they cannot swing closer than two feet to the conductors of circuits of 250 volts or less between conductors, or ten feet to the conductors of circuits of more than 250 volts between conductors except that in the case of circuits not exceeding 150 volts between conductors, where all conductors involved are supported so as to insure permanent separation, the clearance may be reduced but shall not be less than four inches. The clearance between lead-in conductors and any conductor forming a part of a lightning rod system shall be not less than six feet unless the bonding referred to in E-250.086 is accomplished.

(2) Antennas and Lead-Ins - Indoors. Indoor antennas and indoor lead-ins shall not be run nearer than two inches to conductors of other wiring systems in the premises unless:

(a) Such other conductors are in metal raceways or cable armor, or

(b) Unless permanently separated from such other conductors by a continuous and firmly fixed nonconductor such as porcelain tubes or flexible tubing.

E-810.19. Electric Supply Circuits Used in Lieu of Antenna.

Where an electric supply circuit is used in lieu of an antenna, the device by which the radio receiving set is connected to the supply circuit shall be specially approved for the purpose.

Lightning Arresters

E-810.20. Lightning Arresters - Receiving Stations.

Each conductor of a lead-in from an outdoor antenna shall be provided with a lightning arrester approved for the purpose, except that where the lead-in conductors are enclosed in a continuous metallic shield the lightning arrester may be installed to protect the shield or may be omitted where the shield is permanently and effectively grounded. Lightning arresters shall be located outside the building, or inside the building between the point of entrance of the lead-in and the radio set or transformers, and as near as practicable to the entrance of the conductors to the building. The lightning arrester shall not be located near combustible material nor in a hazardous location as defined in Chapter E-500.

Grounding Conductors - General

E-810.21. Material.

The grounding conductor shall, unless otherwise specified, be of copper, aluminum, copper-clad steel, bronze, or other corrosion-resistant material.

E-810.22. Insulation.

The grounding conductors may be uninsulated.

E-810.23. Supports.

The grounding conductors shall be securely fastened in place and may be directly attached to the surface wired over without the use of insulating supports. Where proper support cannot be provided the size of the grounding conductor shall be increased proportionately.

E-810.24. Mechanical Protection.

The grounding conductor shall be protected where exposed to physical damage or the size of the grounding conductor shall be increased proportionately to compensate for the lack of protection.

E-810.25. Run in Straight Line.

The grounding conductor shall be run in as straight a line as practicable from the antenna mast and/or lightning arrester to the grounding electrode.

E-810.26. Grounding Electrode.

The grounding conductor shall be connected to a metallic underground water piping system as specified in E-250.081. Where the building is not supplied with a water system the connection shall be made to the metal frame of the building when effectively grounded or to a grounding electrode as specified in E-250.083. At a penthouse or similar location the ground conductor may be connected to a water pipe or rigid conduit.

Grounding Conductors - Receiving Stations

E-810.27. Inside or Outside Building.

The grounding conductor may be run either inside or outside the building.

E-810.28. Size.

The grounding conductor shall be not smaller than No. 10 copper or No. 8 aluminum or No. 17 copper-clad steel or bronze.

E-810.29. Common Ground.

A single grounding conductor may be used for both protective and operating purposes.

Note: Where a single conductor is so used, the ground terminal of the equipment should be connected to the ground terminal of the protective device.

C. Amateur Transmitting and Receiving Stations

Antenna System

E-810.51. Other Rules.

In addition to conforming to the requirements of Part C, antenna systems for amateur transmitting and receiving stations shall also comply with E-810.11 to E-810.15 inclusive.

E-810.52. Size of Antenna.

Antenna and counter-poise conductors for amateur transmitting and receiving stations shall be of a size not less than given in Table E-810.52.

Table E-810.52

Size of Amateur-Station Outdoor Antenna Conductors

Material	Minimum Size of Conductors: When Maximum Open Span Length is Less than 150 feet	Minimum Size of Conductors: When Maximum Open Span Length is Over 150 feet
Hard-drawn copper	14	10
Copper-clad steel, bronze or other high strength material	14	12

Note: For very long span length larger conductors will be required, depending on the span length and the ice and wind loadings.

E-810.53. Size of Lead-In Conductors.

Lead-in conductors for transmitting stations shall, for various maximum span lengths, be of a size at least as great as that of conductors for antenna as specified in E-810.52.

E-810.54. Clearance on Building.

Antenna and counter-poise conductors for transmitting stations, attached to buildings, shall be firmly mounted at least 3 inches clear of the surface of the building on nonabsorptive insulating supports, such as treated pins or brackets, equipped with insulators having not less than 3-inch creepage and airgap distances. Lead-in conductors attached to buildings shall also conform to these requirements, except when they are enclosed in a continuous metallic shield which is permanently and effectively grounded. In this latter case the metallic shield may also be used as a conductor.

E-810.55. Entrance to Building.

Except where protected with a continuous metallic shield which is permanently and effectively grounded, lead-in conductors for transmitting stations shall enter buildings by one of the following methods:

(1) Through a rigid, noncombustible, nonabsorptive insulating tube or bushing.

(2) Through an opening provided for the purpose in which the entrance conductors are firmly secured so as to provide a clearance of at least 2 inches.

(3) Through a drilled window pane.

E-810.56. Protection Against Accidental Contact.

Lead-in conductors to radio transmitters shall be so located or installed as to make accidental contact with them difficult.

E-810.57. Lightning Arresters. - Transmitting Stations.

Each conductor of a lead-in for outdoor antenna shall be provided with a lightning arrester or other suitable means which will drain static charges from the antenna system.

Exception No. 1. Where protected by a continuous metallic shield which is permanently and effectively grounded.

Exception No. 2. Where the antenna is permanently and effectively grounded.

Grounding Conductors - General

E-810.58. Other Rules.

All grounding conductors for amateur transmitting and receiving stations shall comply with E-810.21 to E-810.27 inclusive.

E-810.59. Size of Protective Ground.

The protective ground conductor for transmitting stations shall be as large as the lead-in, but not smaller than No. 10 copper, bronze, or copper-clad steel.

E-810.60. Size of Operating Grounding Conductor.

The operating grounding conductor for transmitting stations shall be not less than No. 14 copper or its equivalent.

Interior Installation - Transmitting Stations

E-810.70. Clearance From Other Conductors.

Except as provided in Chapter E-640, all conductors inside the building shall be separated at least 4 inches from the conductors of any other light or signal circuit unless separated therefrom by conduit or some firmly fixed non-conductor such as porcelain tubes or flexible tubing.

E-810.71. General.

Transmitters shall comply with the following:

(1) Enclosing. The transmitter shall be enclosed in a metal frame or grille, or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.

(2) Grounding of Controls. All external metallic handles and controls accessible to the operating personnel shall be effectually grounded.

Note: No circuit in excess of 150 volts between conductors should have any parts exposed to direct contact. A complete dead-front type of switchboard is preferred.

(3) Interlocks on Doors. All access doors shall be provided with interlocks which will disconnect all voltages in excess of 350 volts between conductors when any access door is opened.

(4) Audio-Amplifiers. Audio-amplifiers which are located outside the transmitter housing shall be suitably housed and shall be so located as to be readily accessible and adequately ventilated.

CHAPTER E-900

Tables and Examples

A. Tables

Tables 1, 2 and 3 apply only to complete conduit systems, and do not apply to short sections of conduit used for the protection of exposed wiring from physical damage.

Table 1. Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

Derating factors for more than three conductors in raceways, see Tables E-310.12 through E-310.15, Note 8

Types RF-2, RFH-2, R, RH, RW, RH-RW, RHW, RHH, RU, RUH, RUW, SF and SFF
Types TF, T, TW, and THW
(See E-300.17, E-300.18, E-346.06 and E-348.06)

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % conductor fill, Table 3, Chapter E-900, for new work)											
	1/2 Inch	3/4 Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch	3½ Inch	4 Inch	5 Inch	6 Inch
18	7	12	20	35	49	80	115	176				
16	6	10	17	30	41	68	98	150				
14	4	6	10	18	25	41	58	90	121	155		
12	3	5	8	15	21	34	50	76	103	132	208	
10	1	4	7	13	17	29	41	64	86	110	173	
8	1	3	4	7	10	17	25	38	52	67	105	152
6	1	1	3	4	6	10	15	23	32	41	64	93
4	1	1	1	3*	5	8	12	18	24	31	49	72
3		1	1	3	4	7	10	16	21	28	44	63
2		1	1	3	3	6	9	14	19	24	38	55
1		1	1	1	3	4	7	10	14	18	29	42
0			1	1	2	4	6	9	12	16	25	37
00			1	1	1	3	5	8	11	14	22	32
000			1	1	1	3	4	7	9	12	19	27
0000				1	1	2	3	6	8	10	16	23
250				1	1	1	3	5	6	8	13	19
300				1	1	1	3	4	5	7	11	16
350				1	1	1	1	3	5	6	10	15
400					1	1	1	3	4	6	9	13
500					1	1	1	3	4	5	8	11
600						1	1	1	3	4	6	9
700						1	1	1	3	3	6	8
750						1	1	1	3	3	5	8
800						1	1	1	2	3	5	7
900						1	1	1	1	3	4	7
1000						1	1	1	1	3	4	6
1250							1	1	1	1	3	5
1500								1	1	1	3	4
1750								1	1	1	2	4
2000								1	1	1	1	3

*Where an existing service run of conduit or electrical metallic tubing does not exceed 50 ft. in length and does not contain more than the equivalent of two quarterbends from end to end, two No. 4 insulated and one No. 4 bare conductors may be installed in 1-inch conduit or tubing.

Table 2. Trade Sizes of Conduit or Tubing for Number of Conductors

Lead-Covered Types RL and RHL - 600 V.
(See E-346.06 and E-348.06)

Size AWG MCM	Number of Conductors in One Conduit or Tubing											
	Single Conductor Cable				2-Conductor Cable				3-Conductor Cable			
	1	2	3	4	1	2	3	4	1	2	3	4
14	1/2	3/4	3/4	1	3/4	1	1	1-1/4	3/4	1¼	1½	1½
12	1/2	3/4	3/4	1	3/4	1	1¼	1-1/4	1	1¼	1½	2
10	1/2	3/4	1	1	3/4	1¼	1¼	1-1/2	1	1½	2	2
8	1/2	1	1¼	1½	1	1¼	1½	2	1	2	2	2½
6	3/4	1¼	1½	1½	1¼	1½	2	2½	1¼	2½	3	3
4	3/4	1¼	1½	1½	1¼	2	2½	2½	1½	3	3	3½
3	3/4	1¼	1½	2	1¼	2	2½	3	1½	3	3	3½
2	1	1¼	1½	2	1¼	2	2½	3	1½	3	3½	4
1	1	1½	2	2	1½	2½	3	3½	2	3½	4	5
0	1	2	2	2½	2	2½	3	3½	2	4	5	5
00	1	2	2	2½	2	3	3½	4	2½	4	5	5
000	1¼	2	2½	2½	2	3	3½	4	2½	5	5	6
0000	1¼	2½	2½	3	2½	3	3½	5	3	5	6	6
250	1¼	2½	3	3	..	..	..	..	3	6	6	..
300	1½	3	3	3½	..	..	..	..	3½	6	6	..
350	1½	3	3	3½	..	..	..	..	3½	6	6	..
400	1½	3	3	3½	..	..	..	..	3½	6	6	..
500	1½	3	3½	4	..	..	..	..	4	6	..	..
600	2	3½	4	5	..	..	..	..	..	..	..	..
700	2	4	4	5	..	..	..	..	..	..	..	..
750	2	4	4	5	..	..	..	..	..	..	..	..
800	2	4	5	5	..	..	..	..	..	..	..	..
900	2½	4	5	5	..	..	..	..	..	..	..	..
1000	2½	5	5	6	..	..	..	..	..	..	..	..
1250	3	5	5	6	..	..	..	..	..	..	..	..
1500	3	5	6	6	..	..	..	..	..	..	..	..
1750	3	6	6	..	..	..	..	..	..	..	..	..
2000	3½	6	6	..	..	..	..	..	..	..	..	..

The above sizes apply to straight runs or with nominal offsets equivalent to not more than two quarter-bends.

See E-346.10 for bends in conduit.

Table 3. Combination of Conductors
(See E-346.06 and E-348.06)

For groups or combination of conductors not included in Table 1, Chapter E-900, it is recommended that the conduit or tubing be of such size that the sum of the cross-sectional areas of the individual conductors will not be more than the percentage of the interior cross-sectional area of the conduit or tubing shown in the following table:

Per Cent Area of Conduit or Tubing

	Number of Conductors				
	1	2	3	4	Over 4
*Conductors (not lead covered)	53	31	43	40	40
Lead-covered conductors	55	30	40	38	35
**For rewiring existing raceways for increased load where it is impracticable to increase the size of the raceway due to structural conditions.	60	40	50	50	50

Note 1. See Note to Table 5 for size of conduit or tubing for combinations of conductors not shown in Table 1.

Note 2. For carrying capacity of more than three conductors in a conduit or tubing, see Tables E-310.12 through E-310.15, Note 8.

Note 3. See Tables 4 through 7, Chapter E-900, for dimensions of conductors, conduit and tubing.

*Note 4. Use actual dimensions of wire or cable unless it is smaller than dimension of RW. Use dimension of RW as minimum dimension.

**Note 5. For rewiring, figure dimension of wire or cable actually used.

Note 6. For exposed runs of service conduit or tubing not over 30 feet in length, the size of conduit or tubing may be determined as permitted for rewiring.

Note 7. For multi-conductor cables use actual cable cross-section areas. Conductor numbers at head of columns shall be taken as numbers of cables.

Note 8. For bare wires, use actual area from Table 8.

Tables 4 through 7. Chapter E-900. Tables 4 through 7 give the nominal size of conductors and conduit or tubing recommended for use in computing size of conduit or tubing for various combinations of conductors. The dimensions represent average conditions only, and while variations will be found in dimensions of conductors and conduit of different manufacture, these variations will not affect the computation.

Table 4. Dimensions and Per Cent Area of Conduit and of Tubing
Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 3, Chapter E-900.

Trade Size	Internal Diameter Inches	Area - Square Inches												
				Not Lead Covered			Lead Covered					Rewiring Not Lead Covered		
		Total 100%	1 Cond. 53%	2 Cond. 31%	3 Cond. 43%	4 Cond. and over 40%	1 Cond. 55%	2 Cond. 30%	3 Cond. 40%	4 Cond. 38%	Over 4 Cond. 35%	1 Cond. 60%	2 Cond. 40%	3 Cond. and Over 50%
½	.622	.30	.16	.09	.13	.12	.17	.09	.12	.11	.11	.18	.12	.15
3/4	.824	.53	.28	.16	.23	.21	.29	.16	.21	.20	.19	.32	.21	.27
1	1.049	.86	.46	.27	.37	.34	.47	.26	.34	.33	.30	.52	.34	.43
1¼	1.380	1.50	.80	.47	.65	.60	.83	.45	.60	.57	.53	.90	.60	.75
1½	1.610	2.04	1.08	.63	.88	.82	1.12	.61	.82	.78	.71	1.22	.82	1.02
2	2.067	3.36	1.78	1.04	1.44	1.34	1.85	1.01	1.34	1.28	1.18	2.02	1.34	1.68
2½	2.469	4.79	2.54	1.48	2.06	1.92	2.63	1.44	1.92	1.82	1.68	2.87	1.92	2.40
3	3.068	7.38	3.91	2.29	3.17	2.95	4.06	2.21	2.95	2.80	2.58	4.43	2.95	3.69
3½	3.548	9.90	5.25	3.07	4.26	3.96	5.44	2.97	3.96	3.76	3.47	5.94	3.96	4.95
4	4.026	12.72	6.74	3.94	5.47	5.09	7.00	3.82	5.09	4.83	4.45	7.63	5.09	6.36
5	5.047	20.00	10.60	6.20	8.60	8.00	11.00	6.00	8.00	7.60	7.00	9.57	6.38	7.98
6	6.065	28.89	15.31	8.96	12.42	11.56	15.89	8.67	11.56	10.98	10.11	12.00	8.00	10.00
												17.33	11.56	14.45

Table 5. Dimensions of Rubber-Covered and Thermoplastic-Covered Conductors

Size AWG MCM	Types RF-2, RFH-2, R, RH, RHH RHW, RH-RW, RW, THW		Types TF, T, TW, RU**, RUH**, RUW	
	Approx. Diam. Inches	Approx. Area Sq. Ins.	Approx. Diam. Inches	Approx. Area Sq. Ins.
18	.146	.0167	.106	.0088
16	.158	.0196	.118	.0109
14	2/64 in. .171	.0230	.131	.0135
14	3/64 in. .204*	.0327*		
12	2/64 in. .188	.0278	.148	.0172
12	3/64 in. .221*	.0384*		
10	.242	.0460	.168	.0224
8	.311	.0760	.228	.0408
6	.397	.1238	.323	.0819
4	.452	.1605	.372	.1087
3	.481	.1817	.401	.1263
2	.513	.2067	.433	.1473
1	.588	.2715	.508	.2027
0	.629	.3107	.549	.2367
00	.675	.3578	.595	.2781
000	.727	.4151	.647	.3288
0000	.785	.4840	.705	.3904
250	.868	.5917	.788	.4877
300	.933	.6837	.843	.5581
350	.985	.7620	.895	.6291
400	1.032	.8365	.942	.6969
500	1.119	.9834	1.029	.8316
600	1.233	1.1940	1.143	1.0261
700	1.304	1.3355	1.214	1.1575
750	1.339	1.4082	1.249	1.2252
800	1.372	1.4784	1.282	1.2908
900	1.435	1.6173	1.345	1.4208
1000	1.494	1.7531	1.404	1.5482
1250	1.676	2.2062	1.577	1.9532
1500	1.801	2.5475	1.702	2.2748
1750	1.916	2.8895	1.817	2.5930
2000	2.021	3.2079	1.922	2.9013

*The dimensions of Types RW, RHH and THW wire. Also, these dimensions to be used for new work in computing size of conduit or tubing for combinations of wires not shown in Table 1, Chapter E-900.

**No. 14 to No. 2.
No. 18 to No. 8, solid; No. 6 and larger, stranded.

The dimensions of rubber-covered conductors in Column 3 of this Table are to be used in computing the size of conduit or tubing for new work for combinations not shown in Table 1. The dimensions in the last column of this Table may be used only for rewiring existing raceways.

Table 6. Dimensions of Lead-Covered Conductors
Types RL, RHL, and RUL

Size AWG-MCM	Single Conductor		Two Conductor		Three Conductor	
	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.
14	.28	.062	.28 x .47	.115	.59	.273
12	.29	.066	.31 x .54	.146	.62	.301
10	.35	.096	.35 x .59	.180	.68	.363
8	.41	.132	.41 x .71	.255	.82	.528
6	.49	.188	.49 x .86	.369	.97	.738
4	.55	.237	.54 x .96	.457	1.08	.916
2	.60	.283	.61 x 1.08	.578	1.21	1.146
1	.67	.352	.70 x 1.23	.756	1.38	1.49
0	.71	.396	.74 x 1.32	.859	1.47	1.70
00	.76	.454	.79 x 1.41	.980	1.57	1.94
000	.81	.515	.84 x 1.52	1.123	1.69	2.24
0000	.87	.593	.90 x 1.64	1.302	1.85	2.68
250	.98	.754	....	.....	2.02	3.20
300	1.04	.85	....	.....	2.15	3.62
350	1.10	.95	....	.....	2.26	4.02
400	1.14	1.02	....	.....	2.40	4.52
500	1.23	1.18	....	.....	2.59	5.28

Note - No. 14 to No. 8, solid conductors: No. 6 and larger, stranded conductors. Data for 2/64-inch insulation not yet compiled.

Table 7. Dimensions of Asbestos-Varnished-Cambric Insulated Conductors Types AVA, AVB, and AVL

Size AWG MCM	Type AVA		Type AVB		Type AVL	
	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.
14	.245	.047	.205	.033	.320	.080
12	.265	.055	.225	.040	.340	.091
10	.285	.064	.245	.047	.360	.102
8	.310	.075	.270	.057	.390	.119
6	.395	.122	.345	.094	.430	.145
4	.445	.155	.395	.123	.480	.181
2	.505	.200	.460	.166	.570	.255
1	.585	.268	.540	.229	.620	.300
0	.625	.307	.580	.264	.660	.341
00	.670	.353	.625	.307	.705	.390
000	.720	.406	.675	.358	.755	.447
0000	.780	.478	.735	.425	.815	.521
250	.885	.616	.855	.572	.955	.715
300	.940	.692	.910	.649	1.010	.800
350	.995	.778	.965	.731	1.060	.885
400	1.040	.850	1.010	.800	1.105	.960
500	1.125	.995	1.095	.945	1.190	1.118
550	1.165	1.065	1.135	1.01	1.265	1.26
600	1.205	1.140	1.175	1.09	1.305	1.34
650	1.240	1.21	1.210	1.15	1.340	1.41
700	1.275	1.28	1.245	1.22	1.375	1.49
750	1.310	1.35	1.280	1.29	1.410	1.57
800	1.345	1.42	1.315	1.36	1.440	1.63
850	1.375	1.49	1.345	1.43	1.470	1.70
900	1.405	1.55	1.375	1.49	1.505	1.78
950	1.435	1.62	1.405	1.55	1.535	1.85
1,000	1.465	1.69	1.435	1.62	1.565	1.93

Note: No. 14 to No. 8, solid, No. 6 and larger, stranded; except AVL where all sizes are stranded.

Varnished-Cambric Insulated Conductors
Type V

The insulation thickness for varnished-cambric conductors, Type V is the same as for rubber-covered conductors, Type R, except for Nos. 14 and 12 which have 3/64-inch insulation for varnished-cambric and 2/64-inch insulation for rubber-covered conductors and for No. 8 which has 3/64-inch insulation for varnished-cambric, and 4/64-inch insulation for rubber-covered conductors. See Table E-310.02(2). Tables 1 and 2 may, therefore, be used for the number of varnished-cambric insulated conductors in a conduit or tubing.

Table 8. Properties of Conductors

Size AWG	Area Cir. Mils.	Concentric Lay Stranded Conductors		Bare Conductors		D. C. Resistance Ohms/M Ft. at 25°C. 77°F.		
						Copper		Aluminum
		No. Wires	Diam. Each Wire Inches	Diam. Inches	*Area Sq. Inches	Bare Cond.	Tin'd. Cond.	
18	1624	Solid	.0403	.0403	.0013	6.510	6.77	10.9
16	2583	Solid	.0508	.0508	.0020	4.094	4.25	6.85
14	4107	Solid	.0641	.0641	.0032	2.575	2.68	4.31
12	6530	Solid	.0808	.0808	.0051	1.619	1.69	2.71
10	10380	Solid	.1019	.1019	.0081	1.018	1.06	1.70
8	16510	Solid	.1285	.1285	.0130	.641	.660	1.07
6	26250	7	.0612	.184	.027	.410	.426	.674
4	41740	7	.0772	.232	.042	.259	.269	.423
3	52640	7	.0867	.260	.053	.205	.213	.336
2	66370	7	.0974	.292	.067	.162	.169	.266
1	83690	19	.0664	.332	.087	.129	.134	.211
0	105500	19	.0745	.373	.109	.102	.106	.168
00	133100	19	.0837	.418	.137	.0811	.0844	.134
000	167800	19	.0940	.470	.173	.0642	.0668	.105
0000	211600	19	.1055	.528	.219	.0509	.0524	.0837
	250000	37	.0822	.575	.260	.0431	.0444	.0708
	300000	37	.0900	.630	.312	.0360	.0371	.0590
	350000	37	.0973	.681	.364	.0308	.0318	.0506
	400000	37	.1040	.728	.416	.0270	.0278	.0443
	500000	37	.1162	.814	.520	.0216	.0225	.0354
	600000	61	.0992	.893	.626	.0180	.0185	.0295
	700000	61	.1071	.964	.730	.0154	.0159	.0253
	750000	61	.1109	.998	.782	.0144	.0148	.0236
	800000	61	.1145	1.031	.835	.0135	.0139	.0221
	900000	61	.1215	1.093	.938	.0120	.0124	.0197
	1000000	61	.1280	1.152	1.042	.0108	.0111	.0176
	1250000	91	.1172	1.289	1.305	.00864	.00890	.0142
	1500000	91	.1284	1.412	1.566	.00719	.00740	.0118
	1750000	127	.1174	1.526	1.829	.00617	.00636	.0101
	2000000	127	.1255	1.631	2.089	.00539	.00555	.00884

*Area given is that of a circle having a diameter equal to the overall diameter of a stranded conductor.

The values given in the table are those given in Circular 31 of the National Bureau of Standards except that those shown in the 8th column are those given in Specification B33 of the American Society for Testing Materials.

The resistance values given in the last three columns are applicable only to direct current. When conductors larger than No. 4/0 are used with alternating current the multiplying factors in Table 9, Chapter E-900 should be used to compensate for skin effect.

Table 9. Multiplying Factors for Converting D. C. Resistance to 60 Cycle A. C. Resistance

Size	Multiplying Factor			
	For Non-metallic Sheathed Cables in Air or Nonmetallic Conduit		For Metallic Sheathed Cables or all Cables in Metallic Raceways	
	Copper	Aluminum	Copper	Aluminum
Up to 3 AWG	1.	1.	1.	1.
2	1.	1.	1.01	1.00
1	1.	1.	1.01	1.00
0	1.001	1.000	1.02	1.00
00	1.001	1.001	1.03	1.00
000	1.002	1.001	1.04	1.01
0000	1.004	1.002	1.05	1.01
250000 CM	1.005	1.002	1.06	1.02
300000 CM	1.006	1.003	1.07	1.02
350000 CM	1.009	1.004	1.08	1.03
400000 CM	1.011	1.005	1.10	1.04
500000 CM	1.018	1.007	1.13	1.06
600000 CM	1.025	1.010	1.16	1.08
700000 CM	1.034	1.013	1.19	1.11
750000 CM	1.039	1.015	1.21	1.12
800000 CM	1.044	1.017	1.22	1.14
1000000 MCM	1.067	1.026	1.30	1.19
1250000 MCM	1.102	1.040	1.41	1.27
1500000 MCM	1.142	1.058	1.53	1.36
1750000 MCM	1.185	1.079	1.67	1.46
2000000 MCM	1.233	1.100	1.82	1.56

B. Examples

Selection of Conductors. In the following examples, the size of conductor has been selected on the basis of the allowable current-carrying capacities tabulated in the second column of Table E-310.12. If other types of insulated conductors are used, or if the conductors are run open, or with more than three conductors in a raceway, the size of conductor may vary from those shown. Tables E-310.12 through E-310.15 and Notes thereto should be consulted in selecting the size of conductor for a particular installation.

Voltage. For uniform application of the provisions of Chapters E-210, E-215 and E-220 a nominal voltage of 115 and 230 volts shall be used in computing the ampere load on the conductor.

Fractions of an Ampere. Where the computations result in a fraction of an ampere, such fractions may be dropped.

Ranges. For the computation of the range loads in these examples Column A of Table E-220.05 has been used. For optional methods, see Columns B and C of Table E-220.05.

Example No. 1. Single Family Dwelling

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic, and open porches. It has a 12 kw range.

Computed Load (see E-220.04)
General Lighting Load:
1500 sq. ft. at 3 watts per sq. ft. = 4500 watts.

Minimum Number of Branch Circuits Required (see E-220.03)
General Lighting Load:
4500 ÷ 115 = 39.1 amperes; or three 15 ampere 2-wire circuits; or two 20 ampere 2-wire circuits.
Small Appliance Load: Two 2-wire 20 ampere circuits (E-220.03(2))
Minimum Size Feeders Required (see E-220.04)
Computed Load

General Lighting	4500 watts
Small Appl. Load	3000 watts
Total (without range)	7500 watts
3000 watts at 100%	3000 watts
7500 - 3000 = 4500 watts at 35% =	1575 watts
Net computed (without range)	4575 watts
Range Load (see Table E-220.05)	8000 watts
Net computed (with range)	12,575 watts

For 115/230 volt 3-wire system feeders, 12,575 ÷ 230 = 55 amperes

Therefore, feeder size for total load may be selected on basis of 55 ampere load (see E-215.02)

Net computed load exceeds 10 kw. so service conductors shall be 100 amperes (see ~~E-230.04)~~ Exception No. 1).
E-230.041)

Example No. 1(a). Single Family Dwelling

Same conditions as Example No. 1, plus addition of one 6 ampere 230 volt room air conditioning unit and three 12 ampere 115 volt room air conditioning units. See E-422.39, E-422.40 and E-422.41.

From Example No. 1, feeder current is 55 amperes (3 wire, 230 volt)

Line A	Neutral	Line B	
55		55	amperes from Example No. 1
6		6	one 230 volt air cond. motor
12		12	two 115 volt air cond. motors
--		12	one 115 volt air cond. motor
3		3	25% of largest motor (E-430.024)
76		88	amperes per line

Therefore, feeder size for total load may be selected on basis of 88 ampere load.

For feeder overcurrent protection see E-215.04 and E-430.063.

Example No. 1(b). Single Family Dwelling

Optional Calculation for One-Family Dwelling (E-220.07)

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic and open porches. It has a 12 kw range, a 2.5 kw water heater, a 1.2 kw dishwasher, 9 kw of electric space heating installed in five rooms, a 4.5 kw clothes dryer, and a 6 amp. 230 volt room air conditioning unit.

Air conditioner kw is 6 x 230 ÷ 1000 = 1.38 kw

1.38 kw is less than the connected load of 9 kw of space heating; therefore, the air conditioner load need not be included in the service calculation (see E-220.04(12)).

1500 sq. ft. at 3 watts	4.5 kw
Two 20 amp. appliance outlet circuits at 1500 watts each . .	3.0 kw
Range (at nameplate rating)	12.0 kw
Water heater	2.5 kw
Dishwasher	1.2 kw
Space heating	9.0 kw
Clothes dryer	4.5 kw
	36.7 kw

First 10 kw at 100%	= 10.00 kw
Remainder at 40% (26.7 kw x .4)	= 10.68 kw

Calculated load for service size . 20.68 kw = 20,680 watts

20,680 ÷ 230 = 90 amperes

Therefore, this dwelling may be served by a 100 ampere service.

Example No. 1(c). Single Family Dwelling

Optional Calculation for One-Family Dwelling (See E-220.07)

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic and open porches. It has 3 - 20 ampere small appliance circuits, two 4 kw wall-mounted ovens, one 5.1 kw counter-mounted cooking unit, a 4.5 kw water heater, a 1.2 kw dishwasher, a 4.2 kw combination clothes washer and dryer, 6 - 7 ampere 230 volt room air conditioning units and a 1.5 kw permanently installed bathroom space heater.

Air conditioning kw calculation

Total amperes 6 x 7 = 42.00 amperes
25% of largest motor .25 x 7 = 1.75 amperes
43.75 amperes
43.75 x 230 ÷ 1000 = 10.1 kw of air conditioner load

Load included at 100%

Air conditioning . . . . 10.1 kw
Space heater (omit, see E-220.04(12)).

Other Load

1500 sq. ft. at 3 watts	4.5
Three 20 amp. small appliance circuits at 1500 watts	4.5
2 ovens	8.
1 cooking unit	5.1
Water heater	4.5
Dishwasher	1.2
Washer/Dryer	4.2

Total other load 32.0
1st 10 kw at 100% . . . . 10.0 kw
Remainder at 40% (22 kw x .4) . . . . 8.8 kw

Total calculated load . . . . 28.9 kw = 28,900 watts
28,900 ÷ 230 = 126 amperes (service rating)

Example No. 2. Small Roadside Fruitstand With No Show Windows

A small roadside fruitstand with no show windows has a floor area of 150 square feet. The electrical load consists of general lighting and a 1000 watt floodlight. There are no other outlets.

Computed Load (E-220.04)
*General Lighting
150 sq. ft. at 3 watts/sq. ft. x 1.25 = 562 watts
(3 watts/sq. ft. for stores)
562 watts ÷ 115 = 4.88 amperes
One 15 ampere 2-wire branch circuit required (E-220.03)

(Example 2 continued next page)

Example No. 2 (continued)

Minimum Size Service Conductor Required (E-230.041 Exception No. 1)

Computed load . . . . 562 watts
Floodlight load . . . . 1000 watts

Total load . . . . 1562 watts
$1562 \div 115 = 13.6$ amperes

Use No. 8 service conductor (E-230.041 Exception No. 1)
Use a 30 ampere service switch or breaker (E-230.071)

Example No. 3 Store Building

A store 50 feet by 60 feet, or 3,000 square feet, has 30 feet of show window.

Computed Load (E-220.04)

*General lighting load:
3,000 square feet at 3 watts per square foot x 1.25 . . . . 11,250 watts
**Show window lighting load:
30 feet of 200 watts per foot . . . . 6,000 watts

Minimum Number of Branch Circuits Required (E-220.03)

***General lighting load: $11,250 \div 230 = 49$ amperes for 3-wire, 111/230 volts; or 98 amperes for 2-wire, 115 volts:

Three 30 ampere, 2-wire; and one 15 ampere, 2-wire circuits; or
Five 20 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire, and three 15 ampere, 2-wire circuits; or
Seven 15 ampere, 2-wire, circuits; or
Three 15 ampere, 3-wire, and one 15 ampere, 2-wire circuits.

Special lighting load (show window): (E-220.02 Exception No. 2 and E-220.04(2)): $6,000 \div 230 = 26$ amperes for 3-wire, 115/230 volts; or 52 amperes for 2-wire, 115 volts:

Four 15 amperes, 2-wire circuits; or
Three 20 ampere, 2-wire circuits, or
Two 15 ampere, 3-wire circuits.

Minimum Size Feeders (or Service Conductors) Required (E-215.02):

For 115/230 volt, 30wire system:
Ampere load: 49 plus 26 = 75 amperes. (E-220.02):
Size of each feeder, No. 3
For 115 volt system:
Ampere load: 98 plus 52 = 150 amperes (E-220.02):
Size of each feeder, No. 3/0

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*The above examples assume that the entire general lighting load is likely to be used for long periods of time and the load is therefore increased by 25 per cent in accordance with E-220.02. The 25 per cent increase is not applicable to any portion of the load not used for long periods.

**If show window load computed as per E-220.02, the unit load per outlet to be increased 25 per cent.

***The load on individual branch circuits not to exceed 80% of the branch circuit rating (E-210.23(2)).

Example No. 4. Multi-Family Dwelling

Multi-family dwelling having a total floor area of 32,000 square feet with 40 apartments.

Meters in two banks of 20 each and individual sub-feeders to each apartment.

One-half of the apartments are equipped with electric ranges of not exceeding 12 kw each.

Area of each apartment is 800 square feet.

Computed Load for Each Apartment (Chapter E-220):

General lighting load:
800 square feet at 3 watts per square foot . . . . 2,400 watts
Special appliance load:
Electric range . . . . 8,000 watts

Minimum Number of Branch Circuits Required for Each Apartment (E-220.03):

General lighting load: 2,400 ÷ 115 = 21 amperes or two 15 ampere, 2-wire circuits; or two 20 ampere, 2-wire circuits.
Small appliance load: Two 2-wire circuits of No. 12 wire. (See E-220.03(2)).
Range Circuit: 8,000 ÷ 230 = 34 amperes or a circuit of two No. 8's and one No. 10 as permitted by E-210.09(3).

Minimum Size Sub-Feeder Required for Each Apartment (E-215.02):

Computed load (Chapter E-220):	
General lighting load	2,400 watts
Small appliance load, two 20 ampere circuits	3,000 watts
Total computed load (without ranges)	5,400 watts
Application of Demand Factor:	
3,000 watts at 100%	3,000 watts
2,400 watts at 35%	840 watts
Net computed load (without ranges)	3,840 watts
Range load	8,000 watts
Net computed load (with ranges)	11,840 watts

For 115/230 volt, 3-wire system (without ranges):
Net computed load, 3,840 ÷ 230 = 16.7 amperes.
Size of each sub-feeder (see E-215.02).
For 115/230 volt, 3-wire system (with ranges):
Net computed load, 11,840 ÷ 230 = 51.5 amperes.
Size of each ungrounded sub-feeder, No. 6.
Neutral Sub-Feeder:

Lighting and small appliance load	3,840 watts
Range load, 8,000 watts at 70% (see E-220.04(7))	5,600 watts
Net computed load (neutral)	9,440 watts

9,440 ÷ 230 = 41 amperes
Size of neutral sub feeder, No. 6

(Example 4 continued next page)

Minimum Size Feeders Required from Service Equipment to Meter Bank
(For 20 Apartments - 10 with Ranges):

Total Computed Load:

Lighting and small appliance load, 20 x 5,400 . . . . 108,000 watts

Application of Demand Factor:

3,000 watts at 100% . . . . 3,000 watts
105,000 watts at 35% . . . . 36,750 watts
Net computed lighting and small appliance load . . . . 39,750 watts
Range load, 10 ranges (less than 12 kw; Col. A, Table E-220.05) . . . . 25,000 watts
Net computed load (with ranges) . . . . 64,750 watts

For 115/230 volt, 3-wire system:

Net computed load, 64,750 ÷ 230 = 282 amperes.
Size of each ungrounded feeder to each meter bank: 500,000 c.m.

Neutral Feeder:

Lighting and small appliance load . . . . 39,750 watts
Range load: 25,000 watts at 70% (see E-220.04(7) . . . . 17,500 watts
Computed load (neutral) . . . . 57,250 watts
57,250 ÷ 230 = 249 amperes.

Further Demand Factor (E-220.04(7):

200 amperes at 100% = 200 amperes
49 amperes at 70% = 34 amperes
Net computed load (neutral) 234 amperes
Size of neutral feeder to each meter bank: 300,000 c.m.

Minimum Size Main Feeder (or Service Conductors) Required
(For 40 Apartments - 20 with Ranges):

Total computed load:

Lighting and small appliance load, 40 x 5,400 . . . . 216,000 watts

Application of Demand Factor:

3,000 watts at 100% . . . . 3,000 watts
117,000 watts at 35% . . . . 40,950 watts
96,000 watts at 25% . . . . 24,000 watts

Net computed lighting and small appliance load . . . . 67,950 watts
Range load, 20 ranges (less than 12 kw, Col. A, Table E-220.05) . . . . 35,000 watts
Net computed load . . . . 102,950 watts

For 115/230 volt, 3-wire system:

Net computed load, 102,950 ÷ 230 = 448 amperes.
Size of each ungrounded main feeder: 1,000,000 c.m.

Neutral Feeder:

Lighting and small appliance load . . . . 67,950 watts
Range load, 35,000 watts at 70% (see E-220.04(7) . . . . 24,500 watts
Computed load (neutral) . . . . 92,450 watts
92,450 ÷ 230 = 402 amperes.

Further Demand Factor (see E-220.04(7):

200 amperes at 100% = 200 amperes
202 amperes at 70% = 141 amperes
Net computed load (neutral) 341 amperes
Size of neutral main feeder: 600,000 c.m.
See Tables E-310.12 through E-310.15, Notes 8 and 12.

Example No. 5. Calculation of Neutral Feeder (See E-220.04)

The following example illustrates the method of calculating size of neutral feeder for the computed load of a 5-wire, 2-phase system, where it is desired to modify the load in accordance with provisions of E-220.04.

An installation consisting of a computed load of 250 amperes connected between neutral feeder and each ungrounded feeder.

Neutral Feeder (maximum unbalance of load 250 amp. x 140% = 350 amperes):

200 amperes (first) at 100% = 200 amperes
150 amperes (excess) at 70% = 105 amperes

Computed load . . . . 305 amperes

Size of neutral feeder: 500,000 c.m.

Example No. 6. Maximum Demand for Range Loads

Table E-220.05, column A applies to ranges not over 12 kw. The application of Note 1 to ranges over 12 kw (and not over 21 kw) is illustrated in the following examples:

A. Ranges all of same rating.
Assume 24 ranges each rated 16 kw.
From Column A the maximum demand for 24 ranges of 12 kw rating is 39 kw.
16 kw exceeds 12 kw by 4.
5% x 4 = 20% (5% increase for each kw in excess of 12).
39 kw x 20% = 7.8 kw increase.
39 + 7.8 = 46.8 kw: value to be used in selection of feeders.

B. Ranges of unequal rating.
Assume 5 ranges each rated 11 kw.
2 ranges each rated 12 kw.
20 ranges each rated 13.5 kw.
3 ranges each rated 18 kw.
5 x 12 = 60 Use 12 kw for range rated less than 12.
2 x 12 = 24
20 x 13.5 = 270
3 x 18 = 54
408 kw
408 ÷ 30 = 13.6 kw (average to be used for computation)
From Column A the demand for 30 ranges of 12 kw rating is 15 + 30 = 45 kw.
13.6 exceeds 12 by 1.6 (use 2.).
5% x 2 = 10% (5% increase for each kw in excess of 12).
45 kw x 10% = 4.5 kw increase.
45 + 4.5 = 49,5 kw - value to be used in selection of feeders.

Example No. 7. Ranges on a 3-Phase System (See E-220.04(5))

Thirty ranges rated at 12 kw each are supplied by a 3-phase, 4-wire, 120/208-volt feeder, 10 ranges on each phase.

As there are 20 ranges connected to each ungrounded conductor, the load should be calculated on the basis of 20 ranges (or in case of unbalance, twice the maximum number between any two phase wires) since diversity applies only to the number of ranges connected to adjacent phases and not the total.

The current in any one conductor will be one-half the total watt load of two adjacent phases divided by the line-to-neutral voltage. In this case, 20 ranges, from Table E-220.05, will have a total watt load of 35,000 watts for two phases; therefore, the current in the feeder conductor would be:

$$17,500 \div 120 = 146 \text{ amperes.}$$

On a three-phase basis the load would be:

$$3 \times 17,500 = 52,500 \text{ watts.}$$

and the current in each feeder conductor -

$$\frac{52,500}{208 \times 1.73} = 146 \text{ amperes.}$$

Example No. 8. Motors, Conductors, and Overcurrent Protection (See E-430.022, E-430.024, E-430.032 and E-430.052)

Determine the size of conductors, the motor-running overcurrent protection, the branch circuit protection, and the feeder protection, for one 25-h.p. squirrel-cage induction motor (full-voltage starting), and two 30-h.p. wound-rotor induction motors, on a 440-volt, 3-phase, 60-cycle supply.

Conductor Sizes

The full-load current of the 25 h.p. motor is 32 amperes (Table E-430.150). A full-load current of 32 amperes x 1.25 (E-430.022) requires a No. 8, Type R, rubber-covered conductor (Table E-310.12). The full-load current of the 30-h.p. motor is 39 amperes (Table E-410.150). A full-load current of 39 amperes x 1.25 (E-430.022) requires a No. 6, Type R, rubber-covered conductor (Table E-310.12).

The feeder conductor capacity will be 125 per cent of 39, plus 39, plus 32, or 120 amperes (E-430.024). In accordance with Table E-310.12, this would require a No. 0, Type R, rubber-covered feeder.

Note: For Type R conductors run open in air, or for conductors with insulations other than Type R, see Tables E-310.12 through E-310.15.

Overcurrent Protection

Running. The 25-h.p. motor, with full-load current of 32 amperes, must have running overcurrent protection of not over 40 amperes (Columns 2 and 3, Table E-430.146). The 30-h.p. motor with full-load current of 39 amperes must have running overcurrent protection of not over 50 amperes (Columns 2 and 3, Table E-430.146).

Branch Circuit. The branch circuit of the 25-h.p. motor must have branch-circuit overcurrent protection of not over 100 amperes (Column 4, Table E-430.146. The branch circuit of the 30-h.p. motor must have branch-circuit overcurrent protection of not over 60 amperes (Column 7, Table E-430.146).

Feeder Circuit. The rating of the branch-circuit fuse for a 25-h.p. squirrel-cage motor is 300 per cent of 32 amperes, or 96 amperes, which necessitates the use of a 100 ampere standard size fuse (Table E-430.153); and for a 30-h.p. wound rotor motor is 150 per cent of 39 amperes, or 59 amperes (Table E-430.153). The rating of the feeder fuse is, therefore, 100 plus 39 plus 39 which equals 178 amperes, and a 200 ampere fuse is the maximum size which may be used (see E-430.062).

The setting of a motor-branch-circuit circuit-breaker for a 25-h.p. squirrel-cage motor is 250 per cent of 32 amperes or 80 amperes (Table E-430.153); for a 30-h.p. wound-rotor motor is 150 per cent of 39 amperes or 59 amperes (Table E-430.153). The maximum setting of a feeder circuit-breaker is 80 + 39 + 39 = 158 amperes (see E-430.062).