

Chapter E 220

BRANCH CIRCUIT AND FEEDER CALCULATIONS

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E 220.01 Scope. This chapter provides the basis for calculating the expected branch circuit and feeder loads and for determining the number of branch circuits required.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 220.02 Calculation of branch circuit loads. (1) **COMPUTATION.** The load for branch circuits shall be computed in accordance with the provisions of this rule.

(2) **WHEN MAXIMUM LOAD OF BRANCH CIRCUIT CONTINUES FOR LONG PERIOD OF TIME.** Where in normal operation the maximum load will constitute a continuous load, such as store lighting and similar loads, the minimum unit loads specified in this section shall be increased by 25%.

(a) *Exception No. 1.* Where branch circuits are derated in accordance with note 8 of tables E 310.12 through E 310.15, the unit loads are not required to be increased by 25%.

(b) *Exception No. 2.* When the assembly including the overcurrent devices protecting the branch circuits and feeders are approved for operation at 100% of their rating the minimum unit loads need not be increased over those specified.

(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 minimum load conditions and 100% 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.

(b) *In other occupancies.* In other occupancies, a load of not less than the unit load specified in subsection (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 -----	1½ amperes

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

† This provision shall not be applicable to receptacle outlets connected to the circuit specified in section E 220.03 (2) nor to receptacle outlets provided for the connection of stationary equipment as provided for in section E 400.03.

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 -----	3
*Dwellings (other than hotels) -----	3
Garages—Commercial (storage) -----	½
Hospitals -----	2
*Hotels and Motels, including apartment houses without provisions for cooking by tenants -----	2
Industrial, Commercial (loft) Buildings -----	2
Lodge Rooms -----	1½
Office Buildings -----	5
Restaurants -----	2
Schools -----	3
Stores -----	3
Warehouses, Storage -----	¼
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 -----	½
Storage Spaces -----	¼

*All receptacle outlets of 15-ampere or less rating in single-family and multi-family dwellings and in guest rooms of hotels and motels except those connected to the receptacle circuits specified in section E 220.02 (2) may be considered as outlets for general illumination, and no additional load need be included for such outlets. The provisions of section E 220.02 (4) shall apply to all other receptacle outlets.

(5) EXCEPTIONS. The minimum load for outlets specified in subsection (4) shall be modified as follows:

(a) *Exception No. 1. Ranges.* For household electric ranges, the branch circuit load may be computed in accordance with table E 220.05.

(b) *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.

(c) *Exception No. 3. Multi-outlet assemblies.* Where fixed multi-outlet assemblies are employed, each 5 feet or fraction thereof of each separate and continuous length shall be considered as one outlet of not less than 1½ 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 1½ amperes. The requirements of this rule are not applicable to dwellings or the guest rooms of hotels.

(d) *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 subsection (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 subsection (3).

(b) *Other than dwelling occupancies.* When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of subsection (3) or (4) shall apply.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

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 section E 220.03 (2), branch circuits shall be provided for a computed load not less than that determined by section 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 section 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% power factor, see section 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 section E 220.03 (2).

See examples No. 1, 1(a), 1(b), 1(c), and 4, chapter E 900.

(2) **RECEPTACLE CIRCUITS, DWELLING OCCUPANCIES.** (a) For the small appliance load in kitchen, laundry, pantry, family room, dining room and breakfast room of dwelling occupancies, 2 or more 20 ampere branch circuits in addition to the branch circuits specified in subsection (1) shall be provided for all receptacle outlets in these rooms, and such circuits shall have no other outlets.

(b) Receptacle outlets supplied by at least 2 appliance receptacle branch circuits shall be installed in the kitchen.

(c) Receptacle outlets installed solely for the support of and the power supply for electric clocks may be installed on lighting branch circuits.

Note: A 3-wire 115/230 volt branch circuit is the equivalent of two 115 volt receptacle branch circuits.

(3) **FIXED APPLIANCES.** Fixed appliances exceeding $\frac{3}{8}$ hp or 300 watts rating shall not be connected to lighting branch circuits. Where an air conditioner sleeve is provided in a building wall, an outlet within 4 feet of the sleeve location shall be provided. If a circuit is not run to the outlet, a raceway shall be provided. When the air conditioner is added it shall be supplied by a separate circuit. A receptacle outlet installed for an air conditioner shall not be counted as one of the receptacles required by section E 210.22 (2).

(4) **OTHER CIRCUITS.** For specific loads not otherwise provided for in subsections (1), (2), or (3), branch circuits shall be as required by other rules of the code.

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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 section E 220.02, subject to the following provisions:

(1) **GENERAL LIGHTING.** The demand factors listed in subsection (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 subsections E (8) and (9).

Note 2. The demand factors herein are based on minimum load conditions and 100% 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 SECTION 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 3,000 or less at..... Next 3,001 to 120,000 at..... Remainder over 120,000 at.....	100% 85% 25%
*Hospitals.....	First 50,000 or less at..... Remainder over 50,000 at.....	40% 20%
*Hotels and Motels—Including Apartment Houses without provision for cooking by tenants.....	First 20,000 or less at..... Next 20,001 to 100,000 at..... Remainder over 100,000 at.....	50% 40% 30%
Warehouses (Storage).....	First 12,500 or less at..... Remainder over 12,500 at.....	100% 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, hotels and motels 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 sections E 430.024, E 430.025, and E 430.026 shall be included.

(5) **NEUTRAL FEEDER LOAD.** The neutral feeder load shall be the maximum unbalance of the load determined by section 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% 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% of the load on the ungrounded conductors, as determined in accordance with section 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% 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, 1 (a), 1 (b), 1 (c), 2, 3, 4 and 5, chapter E 900. In dwelling occupancies where a 100 ampere minimum service is required [subsection E 230.041 (1)], the neutral may be two sizes smaller than the ungrounded conductors when of the same material.

(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.

(a) *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%, provided the conductors are of sufficient capacity for the load so determined.

(b) *Exception No. 2.* Subsection (6) does not apply when feeder capacity is calculated in accordance with optional method in section 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 subsection (1).

Dwelling Occupancies

Note. The requirements in following sections E 220.04 (9)-(12) apply to dwelling type occupancies and are supplemental to sections 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 1500 watts for each 2-wire circuit installed as required by section E 220.03 (2) 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 2 or more feeders, the computed load for each shall include not less than 1500 watts for each 2-wire circuit for small appliances. These loads may be included with the general lighting load and subject to the demand factors in section E 220.04.

(10) **ELECTRIC RANGES.** The feeder load for household electric ranges and other cooking appliances, individually rated more than 1½ kw, may be calculated in accordance with section 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 8½ 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 ELECTRICAL APPLIANCES (OTHER THAN RANGES, WALL-MOUNTED OVENS, COUNTER-MOUNTED COOKING UNITS, CLOTHES DRYERS, AIR CONDITIONING EQUIPMENT OR SPACE HEATING EQUIPMENT).** Where 4 or more fixed electrical appliances other than electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, air conditioning equipment or space heating equipment are connected to the same feeder in a single or multi-family dwelling, a demand factor of 100% for the largest individual load and 75% for the balance 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 2 loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously.

Note: Permanently installed bathroom heating units are considered fixed appliances and must be included in the load of section (11).

(13) **ELECTRIC CLOTHES DRYERS.** Where provisions are made for installing one or more electric clothes dryers, a feeder load of 5,000 watts or the nameplate rating of the appliance, whichever is larger, shall be included for each dryer, subject to the demand factors of table E 220.06.

(14) **AIR CONDITIONERS.** Where provisions are made for installing one or more air conditioning units, a feeder load of 1,000 watts or the nameplate rating of the appliance, whichever is larger, shall be included for each unit.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

TABLE E 220.05

DEMAND LOADS FOR HOUSEHOLD ELECTRIC RANGES, WALL-MOUNTED OVENS, COUNTER-MOUNTED COOKING UNITS AND OTHER HOUSEHOLD COOKING APPLIANCES OVER 1½ 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 8¾ 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	58%	43%
7	22 kw	58%	40%
8	23 kw	58%	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 ¼	30%	20%
51-60	kw for each	30%	18%
61 and over	range)	30%	16%

Note 1. Over 12 kw to 27 kw ranges all of same kw rating. For ranges, individually rated more than 12 kw but not more than 27 kw, the maximum demand in Column A shall be increased 5% 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 27 kw ranges of unequal ratings. For ranges individually rated more than 12 kw and of different ratings but none exceeding 27 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% for each kw or major fraction thereof by which this average value exceeds 12 kw.

Note 3. The branch circuit load for a commercial range shall be the nameplate rating of the range. The following demand factors may be used to determine the feeder load for commercial cooking appliances: One or two appliances—100%, three appliances—90%, four appliances—80%, and five or more appliances—60%.

Note 4. Over 1½ kw to 8¾ kw. In lieu of the method provided in Column A, loads rated more than 1½ kw but not more than 8¾ 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.

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. The branch circuit load for a counter-mounted cooking unit and not more than 2 wall-mounted ovens, all supplied from a single branch circuit and located in the same room shall be computed by adding the nameplate rating of the individual appliances and treating this total as equivalent to one range.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

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

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 220.07 Optional calculation. For single-family dwellings and individual apartments of multi-family dwellings where the total load of each dwelling unit is supplied by one 3-wire, 100 ampere or larger feeder or set of service entrance conductors, the following percentages may be used in lieu of the method of determining feeder (and service) loads detailed in section 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 4 separately controlled electrical space heating units (see subsection 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 (section E 220.03 (2)); lighting and portable appliances at 3 watts per square foot; all fixed appliances, (including 4 or more separately controlled space heating units [see section 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.

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