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ARTICLE 220 - BRANCH CIRCUIT AND FEEDER CALCULATIONS

220-1. Scope. This Article provides the basis for calculating the expected branch circuit and feeder loads and for determining the number of branch circuits required.

220-2. Calculation of Branch Circuit Loads. The load for branch circuits shall be computed in accordance with the provisions of this Section.

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 per cent.

Exception No. 1. Where branch circuits are derated in accordance with Note 8 of Tables 310-12 through 310-15 the unit loads are not required to be increased by 25 per cent.

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

(a) General Lighting Load.

(1) In Listed Occupancies. In the occupancies listed in Table 220-2(a), a load of not less than the unit load specified shall be included for each square foot of floor area.

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.

The unit values herein are based on minimum load conditions and 100 per cent power factor, and 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 the electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

(2) In Other Occupancies. In other occupancies, a load of not less than the unit load specified in Section 220-2(b) shall be included for each outlet.

(b) 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 1/2 amperes

For motors, see Sections 430-22 and 430-24.

This provision shall not be applicable to receptacle outlets connected to the circuit specified in Section 220-3(b) nor to receptacle outlets provided for the connection of stationary equipment as provided for in Section 400-3.

(c) Exceptions. The minimum load for outlets specified in Section 220-2(b) shall be modified as follows:

Exception No. 1. Ranges. For household electric ranges, the branch circuit load may be computed in accordance with Table 220-5.

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. Multioutlet Assemblies. Where fixed multioutlet 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 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 1/2 amperes. The requirements of this Section are not applicable to dwellings or the guest rooms of hotels.

Table 220-2(a). 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)	1/2
Hospitals	2
*Hotels and Motels, including apartment houses without provisions for cooking by tenants	2
Industrial Commercial (Loft) Buildings	2
Lodge Rooms	1 1/2
Office Buildings	5
Restaurants	2
Schools	3
Stores	3
Warehouses Storage	1/4
In any of the above occupancies except single-family dwellings and individual apartments of multifamily dwellings:	
Assembly Halls and Auditoriums	1
Halls, Corridors, Closets	1/2
Storage Spaces	1/4

*All receptacle outlets of 15-ampere or less rating in single-family and multifamily dwellings and in guest rooms of hotels and motels [except those connected to the receptacle circuits specified in Section 220-3(b)] may be considered as outlets for general illumination, and no additional load need be included for such outlets.

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

The provisions of Section 220-2(b) shall apply to all other receptacle outlets.

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

(1) Dwelling Occupancies. New circuits or extensions to existing circuits may be determined in accordance with Sections 220-2(a or b); 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 Section 220-2(a).

(2) Other Than Dwelling Occupancies. When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of Section 220-2(a or b) shall apply.

220-3. Branch Circuits Required. Branch circuits shall be installed as follows:

(a) Lighting and Appliance Circuits. For lighting, and for appliances, including motor-operated appliances, not specifically provided for in Section 220-3(b), branch circuits shall be provided for a computed load not less than that determined by Section 220-2.

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 210-23.

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.

When lighting units to be installed operate at other than 100 per cent power factor, see Section 210-23(b) for maximum ampere load permitted on branch circuits.

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 220-3(b).

See Examples No. 1, 1a, 1b, 1c, and 4, Chapter 9.

(b) Small Appliance Branch Circuits, Dwelling Occupancies. For the small appliance load in kitchen, pantry, family room, dining room, and breakfast room of dwelling occupancies, two or more 20-ampere appliance branch circuits in addition to the branch circuits specified in Section 220-3 (a) shall be provided for all receptacle outlets in these rooms, and such circuits shall have no other outlets.

Receptacle outlets supplied by at least two appliance receptacle branch circuits shall be installed in the kitchen.

At least one 20-ampere branch circuit shall be provided for laundry receptacle(s) required in Section 210-22(b).

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

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

(c) Other Circuits. For specific loads not otherwise provided for in Section 220-3(a or b), branch circuits shall be as required by other sections of the Code.

220-4. 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 220-2, subject to the following provisions:

(a) General Lighting. The demand factors listed in Table 220-4(a) 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.

See Section 220-4(g and h).

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 220-4(a). 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 Next 3001 to 120,000 at Remainder over 120,000 at	100% 35% 25%
*Hospitals	First 50,000 or less at Remainder over 50,000 at	40% 20%
*Hotels and Motels - Including Apartment Houses without provisions 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.

(b) 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.

(c) Motors. For motors, a load computer according to the provisions of Sections 430-24, 430-25 and 430-26 shall be included.

(d) Neutral Feeder Load. The neutral feeder load shall be the maximum unbalance of the load determined by Section 220-4. 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 Table 220-5. 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 9.

(e) 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 authority enforcing this code 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. Section 220-4(e) does not apply when feeder capacity is calculated in accordance with optional method in Section 220-7 for one-family residences.

(f) Noncoincident 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.

(g) Small Appliances. The computed branch circuit load for receptacle outlets in other than dwelling occupancies, for which the allowance is not more than 1 1/2 amperes per outlet, may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

Dwelling Occupancies

The requirements in following Sections 220-4 (h-k) apply to dwelling type occupancies and are supplemental to the preceding Sections 220-4(a-g).

(h) 1. Small Appliances. 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 two-wire circuit installed as required by Section 220-3(b) shall be included for small appliances (portable appliances supplied from receptacles of 15 or 20 ampere rating) in kitchen, pantry, family room, dining room, and breakfast room. Where the load is subdivided through two or more feeders, the computer load for each shall include not less than 1500 watts for each two-wire circuit for small appliances. These loads may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

2. Laundry Circuit. A feeder load of not less than 1500 watts shall be included for each 2-wire laundry circuit installed as required by Section 220-3(c). This load may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

(i) Electric Ranges. The feeder loads for household electric ranges and other cooking appliances, individually rated more than 1 3/4 kw, may be calculated in accordance with Table 220-5.

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 220-5.

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

See Example 7, Chapter 9.

(j) Fixed Electrical Appliances (Other than Ranges, Clothes Dryers, Air Conditioning Equipment or Space Heating Equipment). Where four or more fixed electrical appliances other than electric ranges, clothes dryers, air conditioning equipment or space heating equipment are connected to the same feeder in a single or multifamily dwelling, a demand factor of 75 per cent may be applied to the fixed appliance load.

(k) 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.

(l) Farm Buildings. Feeders supplying farm buildings (excluding dwellings) or loads consisting of two or more branch circuits shall have minimum capacity computed in accordance with the following table:

Table 220-4(l)

Demand Computation for Farm Buildings or Loads

Load in Amperes at 230 Volts	**Per Cent of Connected Load**
Loads expected to operate without diversity, but not less than 125% full load current of the largest motor and not less than first 60 amperes.	100%
Next 60 Amperes of all other loads	50%
Remainder of other load	25%

Note 1: For service to farm dwelling, see Sections 220-2 through 220-7.

Note 2: For service at main point of delivery to farmstead, see Section 220-4(m).

Table 220-5. 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 3 1/2 kw Rating)	COLUMN C (3 1/2 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 27 kw ranges all of same 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 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 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 per cent for each kw or major fraction thereof by which this average value exceeds 12 kw.

Note 3. This table does not apply to commercial ranges. See Table 220-6(a) for demand factors for commercial cooking equipment.

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 Column 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 220-5. 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 two wall-mounted ovens, all supplied from a single branch circuit and located in the same room shall be computed by adding the nameplate ratings of the individual appliances and treating this total as equivalent to one range.

Table 220-6(a)
Feeder Demand Factors for Commercial Electric Cooking Equipment; including Dishwater Booster Heaters, Water Heaters, and Other Kitchen Equipment.

Number of Units of Equipment	Demand Factors (per cent)
1	100
2	100
3	90
4	80
5	70
6 & over	65

Table 220-6(b)
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 & Over	25

(m) Farm Services.

(1) Service equipment and service entrance conductors, for individual farm buildings (excluding dwellings) shall have minimum capacity computed in accordance with Section 220-4(1).

(2) Minimum capacity of service conductors and service equipment, if any, at the main point of delivery to farms (including dwellings) shall be determined in accordance with the following formula:

100 per cent of the largest demand computed in accordance with Section 220-4(1).

75 per cent of the second largest demand computed in accordance with Section 220-4(1).

65 per cent of the third largest demand computed in accordance with Section 220-4(1).

50 per cent of the demands of remaining loads computed in accordance with Section 220-4(1).

Note 1: Consider as a single computed demand the total of the computed demands of all buildings or loads having the same function.

Note 2: The demand of the farm dwelling, if included in the demands of this formula, should be computed in accordance with Note 1 of Table 220-4(1).

220-7. Optional Calculation for Single Family Dwelling or Individual Apartment of Multifamily Dwelling. For a single family dwelling or individual apartment of a multifamily dwelling served by a 115/230 volt, 3-wire, 100 ampere or larger service where the total load is supplied by one feeder or one set of service entrance conductors, the percentages shown in Table 220-7 may be used in lieu of the method of determining feeder (and service) loads detailed in Section 220-4.

All other load shall include 1500 watts for each 20 ampere appliance circuit [Section 220-3(b)]; lighting and portable appliances at 3 watts per square foot; all fixed appliances, (including four or more separately controlled space heating units [see Section 220-4(k)], 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 9.

Table 220-7
Optional Calculation for Single Family Dwelling or Individual Apartment of Multifamily Dwelling

LOAD (in kw or kva)	Per Cent of Load
Air conditioning and cooling including heat pump compressors [see Section 220-4(k)]	100%
Central electrical space heating [see Section 220-4(k)]	100%
Less than four separately controlled electrical space heating units [see Section 220-4(k)]	100%
First 10 kw of all other load	100%
Remainder of other load	40%

220-8. Optional Calculation for Additional Loads in Existing One-Family Dwelling Occupancy. Load calculations for an existing one-family dwelling occupancy now served by an existing 115/230 volt or 120/208 volt, 3-wire, 60 ampere service may be computed as follows:

Load in KW or KVA	Per Cent of Load
First 8 KW or load at	100%
Remainder of load at	40%

Load calculation shall include lighting and portable appliances at 3 watts per square foot; 1500 watts for each 20 ampere appliance circuit; range or wall-mounted oven and counter-

mounted cooking unit, and other fixed or stationary appliances, at nameplate rating.

If air conditioning equipment or electric space heating equipment is to be installed the following formula shall be applied to determine if the existing service is of sufficient size.

Air conditioning equipment* 100%
Central electrical space heating* 100%
Less than four separately controlled space heating units* 100%
First 8 KW of all other load 100%
Remainder of all other load 40%

Other loads shall include:

1500 watts for each 20 ampere appliance circuit.

Lighting and portable appliances at 3 watts per sq. ft.

Household range or wall-mounted oven and counter-mounted cooking unit.

All other fixed appliances including four or more separately controlled space heating units, at nameplate rating.

*Use larger connected load of air conditioning and space heating, but not both.

220-9. Optional Calculation for Multifamily Dwellings.

(a) For multifamily dwellings equipped with electric cooking equipment, and electric space heating or air conditioning or both, the required demand load for each feeder and for the service entrance conductors may be determined by the following method in lieu of the method of determining feeder (and service) loads detailed in Section 220-4, provided that no individual dwelling unit is supplied by more than one feeder. Any house loads on such feeders shall be calculated in accordance with applicable Sections of Article 220 and shall be added to loads as determined by this Section.

(b) The connected load to which the demand factor applies shall include:

(1) 1500 watts for each 2-wire 20 ampere appliance circuit required by Section 220-3(b) and 1500 watts for each 2-wire 20 ampere laundry circuit installed in accordance with Section 220-3(b).

(2) Lighting and portable appliances at 3 watts per square foot.

(3) All fixed or stationary appliances including ranges, wall-mounted ovens, counter-mounted cooking units, and laundry dryers at nameplate rated load (kva for motors and other low power-factor loads).

(4) Water heaters at nameplate rated load, using only the maximum possible at one time in the case of a water heater with interlocked elements.

(5) The larger load of all space heating units or all air conditioning units, per Section 220-4(k).

Table 220-9

Demand Factors for Feeders and Service Entrance Conductors for Multifamily Dwelling

Number of Dwelling Units	Demand Factor (per cent)
3- 5	45
6- 7	44
8-10	43
11	42
12-13	41
14-15	40
16-17	39
18-20	38
21	37
22-23	36
24-25	35
26-27	34
28-30	33
31	32
32-33	31
34-36	30
37-38	29
39-42	28
43-45	27
46-50	26
51-55	25
56-61	24
62 & over	23