Non-Dwelling Load Calculations

UNIT 13

Objectives

After studying this unit, the student will:

- ✔ have a good understanding of the elements required to perform a non-dwelling load calculation.
- ✔ know that receptacle outlets are counted, unlike dwelling-unit load calculations.
- ✔ understand how to apply Table 220-13 demand factor to receptacle loads in excess of 10 kVA.
- ✔ be able to compute the receptacle load for banks and office buildings where the actual number of receptacle outlets is unknown.
- ✔ be familiar with volt-ampere unit loads for different types of occupancies, and even for different areas within certain occupancies.
- ✔ know when and how to apply Table 220-11 demand factors.
- ✔ be aware that track lighting is computed in addition to the general lighting load.
- ✔ know when to include a sign and/or outline lighting outlet in a load calculation.
- ✔ understand the method for calculating show window lighting loads.
- ✔ be able to determine whether a load is continuous or noncontinuous.
- ✔ understand that continuous loads require the inclusion of an additional 25% volt-ampere rating in the load calculation.
- ✔ know that the load calculation rating represents only a minimum rating.

Introduction

Unit 13 contains a non-dwelling load calculation form, along with a detailed explanation of each line. Dwelling calculations are covered in Unit 8 (one-family) and Unit 11 (multi-family) of this text. Unlike dwelling unit load calculations, receptacle outlets are counted. Receptacle outlets (if known) and fixed multioutlet assemblies (if any) are entered into the calculation, and if the load is great enough, a demand factor is applied. As with dwelling-unit load calculations, general lighting is computed using outside dimensions. Other items, such as a sign outlet (where required) and show window(s) (if present) are part of the non-dwelling load calculation. Continuous Loads (Line 10) is a very important computation. All continuous load ratings must be increased by 25%. While Kitchen Equipment (Line 11) is not included in every type of calculation, be aware that kitchen equipment is not limited to restaurants. For instance, kitchen equipment could be a portion of a load calculation for a school. Line 14 (All Other Loads) is a catchall for any load not included otherwise in the calculation.

The load calculation form has little room for listing individual items, such as motors, equipment, etc. Depending upon the size of the occupancy, the calculation could contain hundreds, if not thousands, of individual items. Space is also limited for certain calculations. When the need arises, simply attach additional sheets of paper containing extra items and/or calculations. Some procedure(s) will not apply to certain load calculations. It is recommended that a line not be left completely empty. Some predetermined marking should fill the space; i.e., a dashed line, the letters NA, etc. One of the procedures (Line 4) is applicable only in banks and office buildings where the actual number of receptacle outlets is unknown.

The load calculation form results (overcurrent protection and conductors) represent only a *minimum* requirement. No consideration is given for the addition of future electrical loads. The size service and/or feeder is not restricted to the form's calculated size. For example, an electrician might install a 200-ampere service in an occupancy where the load calculation only required a 125-ampere rating.

Because certain cities, states, etc. require that some (if not all) electrical installations be designed by a licensed Electrical Engineer, caution is advised. Check with local authorities to determine these, as well as other, requirements.

NON-DWELLING LOAD CALCULATIONS

Line 1—Receptacle Load

General purpose receptacles are not continuous loads.

Receptacle outlets are computed at a minimum of 180 volt-amperes for each single (or multiple) receptacle on one strap »220-3(b)(9)« (See Unit 12).

1	Receptacle Load (noncontinuous) 220-3(b)(9) *Multiply each single or multiple receptacle on one strap by 180 volt-amperes.* *Multiply each single piece of equipment comprised of 4 or more receptacles by 90 VA per receptacle.*	1	

A load of 15,300 volt-amperes would be placed in Line 1 for a commercial occupancy having 75 duplex and 10 single receptacles. (75 + 10 = 85 × 180 = 15,300)

A single piece of equipment (consisting of four or more receptacles) must be computed at no less than 90 volt-amperes per receptacle »220-3(b)(9)« (See Unit 12).

NOTE

Because receptacles located in hotel/motel guest rooms are included in the general lighting load calculation, no additional load calculation is required.

Line 2—Fixed Multioutlet Assembly Load

Where simultaneous use of appliances is unlikely, each 5 feet or fraction thereof (of separate and continuous lengths) are considered one outlet of no less than 180 volt-amperes »220-3(b)(8)(a)«. The number of receptacles within the 5-foot measurement is irrelevant.

2	Fixed Multioutlet Assemblies (noncontinuous) 220-3(b)(8) *Where not likely to be used simultaneously, multiply each 5 foot section by 180 volt-amperes.* *Where likely to be used simultaneously, multiply each 1 foot section by 180 volt-amperes.*	2	

Where simultaneous use of appliances is likely, each 1 foot or fraction thereof shall be considered one outlet of no less than 180 volt-amperes »220-3(b)(8)(b)«.

A commercial occupancy has 75 linear feet of fixed multioutlet assembly, with 15 feet of the assembly subject to simultaneous use. A load of 4,860 volt-amperes is placed in Line 2, because 75 – 15 = 60 feet (non-simultaneous); 60 ÷ 5 = 12 × 180 = 2,160 volt-amperes for non-simultaneous use multioutlet assembly; 15 × 180 = 2,700 volt-amperes for simultaneous use multioutlet assembly, and; 2,160 + 2,700 = 4,860 volt-amperes total for multioutlet assembly.

NOTE

Because fixed multioutlet assemblies in hotel/motel guest rooms are included in the general lighting load calculation, no additional load calculation is needed.

Non-dwelling Feeder/Service Load Calculation

1	Receptacle Load (noncontinuous) 220-3(b)(9) *Multiply each single or multiple receptacle on one strap by 180 volt-amperes.* *Multiply each single piece of equipment comprised of 4 or more receptacles by 90 VA per receptacle.*	1	
2	Fixed Multioutlet Assemblies (noncontinuous) 220-3(b)(8) *Where not likely to be used simultaneously, multiply each 5 foot section by 180 volt-amperes.* *Where likely to be used simultaneously, multiply each 1 foot section by 180 volt-amperes.*	2	
3	Receptacle Load Demand Factor (for nondwelling receptacles) 220-13 *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220-13.* *Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then, multiply the remainder by 50%.*	3	
4	Unknown Receptacle Load (Banks and Office buildings only) *Where the actual number of general purpose receptacle outlets are unknown, include 1 volt-ampere per sq. ft. Table 220-3(a) footnote [b]* 1 × ____________ = (sq. ft. outside dimensions)	4	
5	General Lighting Load Table 220-3(a) *Multiply the volt-ampere unit load (for the type of occupancy) by the square foot outside dimensions.* ________ × ____________ = (VA unit load) (sq. ft. outside dimensions)	5	
6	Lighting Load Demand Factors 220-11 . . . *Apply Table 220-11 demand factors to certain portions of hospitals, hotels, motels, apartment houses (without provisions for cooking), and storage warehouses. Do not include areas in hospitals, hotels, and motels where the entire lighting will be used at one time.*	6	
7	Track Lighting (in addition to general lighting) 220-12(b) *Include 150 volt-amperes for every 2 feet, or fraction thereof, for lighting track.* ________ ÷ 2 ________ × 150 = (total linear feet)	7	
8	Sign and/or Outline Lighting Outlet (where required) 220-3(b)(6) *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600-5(a) Each outlet must be at least 1,200 volt-amperes.*	8	
9	Show Window Lighting 220-12(a) *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.* ____________ × 200 = (total linear feet of show window)	9	
10	Continuous Loads 215-2(a), 215-3, and 230-42(a) . . . *Multiply the continuous load volt-amperes (listed above) by 25%. (General purpose receptacles are not considered continuous.)* ____________ × 25% = (total continuous load volt-amperes)	10	
11	Kitchen Equipment 220-20 *Multiply three or more pieces of equipment by Table 220-20 demand factor (percent).* Use Table 220-19 for household cooking equipment used in instructional programs. Table 220-19 Note 5	11	
12	Noncoincident Loads 220-21 . . . *The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems). Calculate fixed electric space heating loads at 100% of the total connected load. 220-15*	12	
13	Motor Loads 220-4(a), 430-24, 430-25, 430-26, and Article 440 *Motor-driven air-conditioning and refrigeration equipment is found in Article 440.* *Multiply the largest motor (one motor only) by 25% and add to load.*	13	
14	All Other Loads . . . *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*	14	
15	Total Volt-Ampere Demand Load: *Add Lines 3 through 14 to find the minimum required volt-amperes.*	15	
16	Minimum Amperes *Divide the total volt-amperes by the voltage* ________ ÷ ________ = (line 15) (voltage) **16** ________ (minimum amperes) **17 Minimum Size Service and/or Feeder 240-6(a)**	17	
18	Size the Service and/or Feeder Conductors. Tables 310-16 through 310-19 *Use the tables along with Section 310-15(b)(1) through (7) to determine conductor size. If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240-3(c)* **Minimum Size Conductors**	18	
19	Size the Neutral Conductor 220-22 *The neutral service and/or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. Section 250-24(b)(1) states that the neutral cannot be smaller than the required grounding electrode conductor specified in Table 250-66. A further demand factor is permitted for any neutral load over 200 amperes.* **Minimum Size Neutral Conductor**	19	
20	Size the Grounding Electrode Conductor (for Service) 250-66 *Using line 18 to find the grounding electrode conductor in Table 250-66.* Size the Equipment Grounding Conductor (for Feeder) 250-122 *Use line 17 to find the equipment grounding conductor in Table 250-122.* *Equipment grounding conductor types are listed in Section 250-118.* **Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	

Line 3—Receptacle Load Demand Factor

Receptacle loads in other than dwelling units are computed at no more than 180 volt-amperes per outlet in accordance with Section 220-3(b)(9) and fixed multioutlet assemblies are computed per Section 220-3(b)(8). Both can be added to the lighting load and made subject to the demand factors given in Table 220-11, or they can be made subject to Table 220-13 demand factors »220-13«.

If the total receptacle load is no more than 10,000 volt-amperes, insert the number directly in Line 3.

3 Receptacle Load Demand Factor (for nondwelling receptacles) 220-13 *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220-13. Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then, multiply the remainder by 50%.*	**3**	

If the total receptacle load is more than 10,000 volt-amperes, subtract 10,000 from the total, and multiply the remainder by 50%. Finally, add that number to the original 10,000 and place the total in Line 3.

A commercial occupancy has a receptacle load of 15,300 volt-amperes and a fixed multioutlet assembly load of 4,860. The total receptacle load is 20,160 volt-amperes. First, subtract 10,000 from the total receptacle load (20,160 – 10,000 = 10,160). Next, multiply the remainder by 50% (10,160 × 50% = 5,080). Finally, add the result back to the original 10,000 volt-amperes (5,080 + 10,000 = 15,080). The receptacle load, after demand, is then entered into Line 3.

NOTE

General purpose receptacles are not considered continuous loads.

Line 4—Unknown Receptacle Load

In addition, a unit load of 1 volt-ampere per square foot must be included for general purpose receptacle outlets where the actual number is unknown »Table 220-3(a) footnote [b]«.

If the actual number of general purpose receptacle outlets in a bank or office building is known, Line 4 would not contain a number.

Line 4 would contain a figure only if the occupancy is a bank or office building.

4 Unknown Receptacle Load (Banks and Office buildings only) *Where the actual number of general purpose receptacle outlets are unknown, include 1 volt-ampere per sq. ft. Table 220-3(a) footnote [b]* 1 × ________ (sq. ft. outside dimensions) =	**4**	

It is not known how many receptacles are in an 8,500-square-foot bank. A load of 8,500 volt-amperes should be placed in Line 4 (8,500 × 1 = 8,500). Since the actual number of receptacle outlets is unknown, Line 3 would not contain a number.

CAUTION

Line 4 applies only to bank and office building occupancies.

Line 5—General Lighting Load

A unit load which meets or exceeds that specified in Table 220-3(a) for occupancies listed therein constitutes the minimum lighting load for each square foot of floor area »220-3(a)«.

Find the correct volt-ampere unit load located across from the occupancy type, and insert into the calculation »Table 220-3(a)«.

Each floor's area must be computed using the building's (or area's) outside dimensions »220-3(a)«.

5	General Lighting Load Table 220-3(a) *Multiply the volt-ampere unit load (for the type of occupancy) by the square foot outside dimensions.*	________ × ________ = (VA unit load) (sq. ft. outside dimensions)	5

An 8,500-square-foot bank has a general lighting load of 29,750 volt-amperes (8,500 × 3.5 = 29,750). The receptacle load, whether known or unknown, is not used here.

A 30,000-square-foot store has a general lighting load of 90,000 volt-amperes (30,000 × 3 = 90,000).

NOTE

In all Table 220-3(a) occupancies (except one-family dwellings and individual dwelling units of two-family and multifamily dwellings), specific areas can be separately multiplied by different volt-ampere unit loads. For example: assembly halls and auditoriums have a unit load of 1; halls, corridors, closets, and stairways have a unit load of 0.5; and storage spaces have a unit load of 0.25 volt-amperes per square foot.

Line 6—Lighting Load Demand Factors

NOTE

Do not use Table 220-11 to determine the total number of branch circuits »220-11«.

Demand factors apply to certain areas in hospitals, hotels, motels, apartment houses (without cooking provisions), and warehouses.

6	Lighting Load Demand Factors 220-11 . . . *Apply Table 220-11 demand factors to certain portions of hospitals, hotels, motels, apartment houses (without provisions for cooking), and storage warehouses. Do not include areas in hospitals, hotels, and motels where the entire lighting will be used at one time.*	6

Do not include areas in hospitals, hotels, and motels where all lighting is subject to simultaneous use. Primarily, such lighting is considered continuous loads. Continuous loads must not be derated by Table 220-11, but instead, are increased by 25% (Line 10).

After demand, the general lighting load for hospital patients' rooms, where the room dimensions total 100,000 square feet is 30,000 volt-amperes. First, multiply 100,000 by the hospital volt-ampere unit load (2), found in Table 220-3(a) (100,000 × 2 = 200,000). Next, multiply the first 50,000 by 40% (50,000 × 40% = 20,000). Then, multiply the remainder by 20% (100,000 – 50,000 = 50,000 × 20% = 10,000). Finally, add the two figures (20,000 + 10,000 = 30,000).

Line 7—Track Lighting

Do not consider track lighting in dwelling unit (or hotel/motel guest room) service and/or feeder load calculations »220-12(b)«.

Track lighting is calculated in addition to the occupancy general lighting load, found in Table 220-3(a).

A store having 80 feet of lighting track has an additional lighting load of 6,000 volt-amperes. First, divide the total length of lighting track by two (80 ÷ 2 = 40). Then, multiply the result by 150 volt-amperes (40 × 150 = 6,000).

7	Track Lighting (in addition to general lighting) 220-12(b) *Include 150 volt-amperes for every 2 feet, or fraction thereof, for lighting track.*	________ ÷ 2 ________ × 150 = (total linear feet)	7

Multiply each 2 foot section, or fraction thereof, by 150 volt-amperes »220-12(b)«.

Line 8—Sign and Outline Lighting

Each commercial building (or occupancy) open to pedestrians must be provided with at least one outlet in a location accessible to each tenant space entrance for sign or outline lighting system use »220-3(b)(6)«.

NOTE

Because service hallways or corridors are not considered accessible to pedestrians, no circuit is required »220-3(b)(6)«.

8	Sign and/or Outline Lighting Outlet (where required) 220-3(b)(6) *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600-5(a) Each outlet must be at least 1,200 volt-amperes.*	**8**	

CAUTION «««««««««««««

If the rating is more than 1,200 volt-amperes, use the actual rating of the sign and/or outline lighting.

Each sign and outline lighting outlet is computed at a minimum of 1,200 volt-amperes »220-3(b)(6)«.

Line 9—Show Window Lighting

If an occupancy has show window(s), include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base »220-12(a)«.

NOTE

Calculate show window branch circuits in accordance with Section 220-3(b)(6).

A store having 75 linear feet of show window space has a feeder/service load of 15,000 volt-amperes (75 × 200 = 15,000).

9	Show Window Lighting 220-12(a) *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.*	________ × 200 = (total linear feet of show window)	**9**	

Line 10—Continuous Loads

A load where the maximum current is expected to continue for 3 hours or more is a continuous load »Article 100«.

Feeder conductors and overcurrent protection must be sized at 100% of noncontinuous loads *plus* 125% of continuous loads »215-2(a) and 215-3«. In other words, an additional 25% of the volt-ampere rating must be added to the continuous loads. This form simplifies that computation. Add all of the continuous loads (listed above Line 10) and multiply by 25%. This rule also applies to service entrance conductors »230-42(a)«.

10	Continuous Loads 215-2(a), 215-3, and 230-42(a) . . . *Multiply the continuous load volt-amperes (listed above) by 25%. (General purpose receptacles are not considered continuous.)*	________ × 25% = (total continuous load volt-amperes)	**10**	

General purpose receptacles and multioutlet assemblies are not included in this calculation.

Total all of the *continuous* loads listed in Lines 5 through 9. These lines are not automatically considered continuous. Only if the load is expected to continue for 3 hours or more is it a continuous load. Examples may include, but are not limited to: general lighting, track lighting, show window lighting, signs and outline lighting.

Line 11—Kitchen Equipment

Compute the load for commercial electric cooking equipment, dishwasher booster heaters, water heaters, and other kitchen equipment in accordance with Table 220-20. Apply the demand factors to all equipment that: (1) has thermostatic control, or; (2) is intermittently used as kitchen equipment »220-20«.

Table 220-20 is relatively simple. No derating is allowed for only 1 or 2 pieces of equipment. The demand factor for 3 pieces of equipment is 90%; for 4 pieces, 80%; and for 5 pieces, 70%. The demand factor for more than 5 pieces of equipment is 65%.

NOTE

Table 220-20 does not apply to space-heating, ventilating, or air-conditioning equipment.

11 Kitchen Equipment 220-20 *Multiply three or more pieces of equipment by Table 220-20 demand factor (percent).* Use Table 220-19 for household cooking equipment used in instructional programs. Table 220-19 Note 5	**11**	

CAUTION

The feeder or service demand load can never be smaller than the combined rating of the two largest kitchen equipment loads »220-20«.

For household cooking appliances rated over 1¾ kW and used in instructional programs, refer to Table 220-19 »Table 220-19 Note 5«. For example, a feeder supplying twenty 12-kW household electric ranges, in a school home-economics classroom, requires a minimum rating of only 35 kW »Table 220-19, Column A«.

Line 12—Noncoincident Loads

NOTE

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 having jurisdiction may grant permission for feeder conductors to have an ampacity less than 100 percent, provided the conductors have an ampacity for the load so determined »220-15 Exception*«.*

Where it is unlikely that multiple noncoincident loads will be used simultaneously, use only the largest load(s) that will be used at one time, in computing the total feeder/service load »220-21«.

12 Noncoincident Loads 220-21 . . . *The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems). Calculate fixed electric space heating loads at 100% of the total connected load. 220-15*	**12**	

While fixed electric space heating loads are computed at 100% of the total connected load, in no case shall a feeder or service load current rating be less than the rating of the largest branch circuit supplied »220-15«.

Line 13—Motor Loads

The ampacity of the conductors supplying multi-motor and combination-load equipment must not be less than the minimum circuit ampacity marked on the equipment per Section 430-7(d). If the individual equipment nameplates are visible (per Section 430-7(d)(2), but the equipment is not factory-wired, use Section 430-24 to determine conductor ampacity »430-25«.

Where conductor heating is reduced as a result of motors operating on duty-cycle, intermittently, or from all motors not operating at one time, the authority having jurisdiction may grant permission for feeder conductors to have an ampacity less than specified in Section 430-24, provided the conductors have sufficient ampacity for the number of motors supplied and the nature of the their loads and duties »430-26«.

13 Motor Loads 220-4(a), 430-24, 430-25, 430-26, and Article 440 *Motor-driven air-conditioning and refrigeration equipment is found in Article 440.* *Multiply the largest motor (one motor only) by 25% and add to load.*	**13**	

Conductors supplying several motors, or a motor(s) and other load(s), must have an ampacity at least equal to the sum of the full-load current rating of all the motors (as determined by Section 430-6(a)(1), *plus* 25 percent of the highest-rated motor in the group »430-24«.

Where one or more of the motors of the group are used for short-time, intermittent, periodic, or varying duty, the ampere rating of such motors used in the summation shall be determined in accordance with Section 430-22(b). For the highest-rated motor, the greater of either the ampere rating from 430-22(b) or the largest continuous-duty motor full-load current multiplied by 1.25 must be used in the summation »430-24 *Exception No.1*«.

Where interlocked circuitry prevents operation of selected motors or other loads at the same time, the conductor ampacity can be based on the summation of the currents of the motors and other loads being operated at the same time resulting in the highest total current »430-24 *Exception No.3*«.

Line 14—All Other Loads

This line is a catchall for loads not falling into one of the previous categories.

Calculate all noncontinuous loads (not yet input) at 100% of their volt-ampere rating.

14 All Other Loads . . . *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*	**14**	

Total all continuous loads (not yet calculated) and multiply by 125%. Add the result of the continuous loads to that for noncontinuous loads and put the total on Line14.

Line 15—Total Volt-Ampere Demand Load

Add all volt-ampere loads listed in Lines 3 through 14 and place the result in Line 15.

15 Total Volt-Ampere Demand Load: *Add Lines 3 through 14 to find the minimum required volt-amperes.*	**15**	

NOTE

Not all lines will contain volt-ampere loads. Be sure to add only the lines containing loads. For example, if the actual number of receptacles in a bank are known, Line 4 will not contain a figure.

Lines 16 and 17—Minimum Size Service and/or Feeder

Place the total volt-ampere amount found in Line 15 here.

Write down the source voltage that supplies the feeder/service.

Fractions of an ampere 0.5 and higher are rounded up, while fractions less than 0.5 are dropped »220-2(b)«.

The service (or feeder) overcurrent protection must be higher than the number found in Line 16. Refer to Section 240-6(a) for a list of fuse and circuit breaker standard ampere ratings.

16 Minimum Amperes *Divide the total volt-amperes by the voltage*	______ (line 15) ÷ ______ (voltage) =	**16**	(minimum amperes)	**17**	**Minimum Size Service and/or Feeder 240-6(a)**	**17**	

Divide the volt-amperes by the voltage to find the amperage.

Three-phase voltage is found by multiplying the voltage (single-phase) by 1.732. For example, the source voltage for 208-volt, three-phase is 360 (208 × 1.732).

The result on Line 16 is the minimum amperage rating required for the service and/or feeder being calculated.

Line 18—Minimum Size Conductors

No. 1/0 and larger conductors can be connected in parallel (electrically joined at both ends to form a single conductor) »310-4«.

The number and type of paralleled conductor sets is a design consideration, not necessarily a *Code* issue. Exercise extreme care when designing a paralleled conductor installation without violating provisions, such as 110-14(a), 110-14(c), 240-3(c), 250-66, 250-122(f), 300-20(a), 310-4, etc.

Using Tables 310-16 through 310-19, choose a conductor size which equals (or exceeds) Line 16's minimum ampacity rating. The conductor's ampacity rating does not have to equal or exceed the overcurrent device rating unless its rating exceeds 800 amperes »240-3(b)«.

Ampacity adjustment (correction) factors for more than three current-carrying conductors are located in Table 310-15(b)(2).

18 Size the Service and/or Feeder Conductors. Tables 310-16 through 310-19 *Use the tables along with Section 310-15(b)(1) through (7) to determine conductor size. If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240-3(c)*	**Minimum Size Conductors**	**18**	

WARNING

For overcurrent devices rated over 800 amperes, the ampacity of the conductors protected must equal or exceed the rating of the overcurrent device per Section 240-6 »240-3(c)«. Do not exceed the temperature limitations outlined in Section 110-14(c).

NOTE

The paralleled conductors in each phase, neutral, or grounded circuit conductor must share the same characteristics »310-4«. For example, all paralleled, Phase A conductors must:

(1) be of the same length,
(2) have the same conductor material,
(3) be the same size in circular mil area,
(4) have the same insulation type,
(5) be terminated in the same manner.

Line 19—Neutral Conductor

For the purpose of this load calculation, the term **Neutral** and **Grounded** are synonymous.

The feeder (or service) neutral load is the maximum unbalance of the load determined by Article 220 »220-22«.

NOTE

The neutral must not be smaller than the required grounding electrode conductor specified in Table 250-66 »250-24(b)(1)«.

19 Size the Neutral Conductor 220-22 *The neutral service and/or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. Section 250-24(b)(1) states that the neutral cannot be smaller than the required grounding electrode conductor specified in Table 250-66. A further demand factor is permitted for any neutral load over 200 amperes.*	**Minimum Size Neutral Conductor**	**19**	

CAUTION

Reduction of neutral capacity is not permitted for that portion of the load that consists of nonlinear loads supplied from a 4-wire, wye-connected, 3-phase system nor the grounded conductor of a 3-wire circuit consisting of two phase wires and the neutral of a 4-wire, 3-phase, wye-connected system »220-22«.

In addition to 220-22 demand factors, a 70% demand factor is permitted for that portion of the unbalanced load above 200 amperes »220-22«.

The neutral is sized by finding the maximum unbalanced load.

Include all lighting and receptacle loads having a 120-volt rating in the neutral calculation.

All appliances, equipment, motors, etc. utilizing a grounded conductor are included in the neutral calculation.

Line 20—Grounding Conductor

Grounding electrode conductor size is based on the largest service-entrance conductor or equivalent area for parallel conductors »Table 250-66«. (The minimum size service-entrance conductors were determined on Line 18.)

While Table 250-66 is used for service installations, it is also used in other wiring applications, such as separately derived systems »250-30(a)(2)«, and connections at separate buildings or structures »250-32«.

Where the grounding electrode conductor connects to made electrode, and that conductor portion is the sole grounding electrode connection, the maximum size required is No. 6 copper or No. 4 aluminum »250-66(a)«.

For a grounding electrode conductor connected to a concrete-encased electrode, serving as the only grounding electrode connection, the maximum size required is No. 4 copper »250-66(b)«.

If the grounding electrode conductor is connected to a ground ring, and that conductor portion is the sole connection to the grounding electrode, the maximum size required is the size used for the ground ring »250-66(c)«.

20 Size the Grounding Electrode Conductor (for Service) 250-66 *Using line 18 to find the grounding electrode conductor in Table 250-66.* Size the Equipment Grounding Conductor (for Feeder) 250-122 *Use line 17 to find the equipment grounding conductor in Table 250-122. Equipment grounding conductor types are listed in Section 250-118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**20**	

While the equipment bonding jumper on the load side of the service overcurrent devices must be sized, as a minimum, in accordance with Table 250-122 sizes, they do not have to be larger than the circuit conductors supplying the equipment »250-102(d)«.

The equipment grounding conductor size is based on the rating (or setting) of the circuit's automatic overcurrent device ahead of equipment, conduit, etc. »Table 250-122«.

ARTICLE 220 Branch-Circuit, Feeder, and Service Calculations

I. General

220.1 Scope.

This article provides requirements for computing branch-circuit, feeder, and service loads.

Exception: Branch-circuit and feeder calculations for electrolytic cells as covered in 668.3(C)(1) and (4).

The scope of Article 220 was previously revised to clearly indicate that the article deals with load computation for branch-circuit, feeder, and service loads and not with requirements for determining the number of branch circuits needed. The determination for the number of branch circuits is contained in Article 210.

220.2 Computations.

(A) Voltages. Unless other voltages are specified, for purposes of computing branch-circuit and feeder loads, nominal system voltages of 120, 120/240, 208Y/120, 240, 347, 480Y/277, 480, 600Y/347, and 600 volts shall be used.

(B) Fractions of an Ampere. Where computations result in a fraction of an ampere that is less than 0.5, such fractions shall be permitted to be dropped.

For uniform calculation of load, nominal voltages, as listed in 220.2(A), are required to be used in computing the ampere load on the conductors. To select conductor sizes, refer to 310.15(A) and (B).

Loads are computed on the basis of volt-amperes (VA) or kilovolt-amperes (kVA), rather than watts or kilowatts (kW), to calculate the true ampere values. However, the rating of equipment is given in watts or kilowatts for noninductive loads. Such ratings are considered to be the equivalent of the same rating in volt-amperes or kilovolt-amperes. See, for example, 220.19. This concept recognizes that load calculations determine conductor and circuit sizes, that the power factor of the load is often unknown, and that the conductor “sees” the circuit volt-amperes only, not the circuit power (watts).

See Examples D1(a) through D5(b) of Annex D. The results of these examples are generally expressed in amperes. Unless the computations result in a major fraction of an ampere (0.5 or larger), such fractions (less than 0.5) may be dropped.

220.3 Computation of Branch Circuit Loads.

Branch-circuit loads shall be computed as shown in 220.3(A) through (C).

(A) Lighting Load for Specified Occupancies. A unit load of not less than that specified in

Table 220.3(A) for occupancies specified therein shall constitute the minimum lighting load. The floor area for each floor shall be computed from the outside dimensions of the building, dwelling unit, or other area involved. For dwelling units, the computed floor area shall not include open porches, garages, or unused or unfinished spaces not adaptable for future use.

FPN:The unit values herein are based on minimum load conditions and 100 percent power factor and may not provide sufficient capacity for the installation contemplated.

General lighting loads determined by 220.3(A) are in fact minimum lighting loads, and there are no exceptions to these requirements. Therefore, energy saving-type calculations are not permitted to be used to determine the minimum calculated lighting load, if they produce loads less than the load calculated according to 220.3(A). On the other hand, energy saving-type calculations can be a useful tool to reduce the connected lighting load.

Examples of unused or unfinished spaces for dwelling units are some attics, cellars, and crawl spaces.

Table 220.3(A) General Lighting Loads by Occupancy

	Unit Load	
Type of Occupancy	**Volt-Amperes per Square Meter**	**Volt-Amperes per Sq Foot**
Armories and auditoriums	11	1
Banks	39[b]	$3^{1}/_{2}$[b]
Barber shops and beauty parlors	33	3
Churches	11	1
Clubs	22	2
Court rooms	22	2
Dwelling units[a]	33	3
Garages — commercial (storage)	6	$^{1}/_{2}$
Hospitals	22	2
Hotels and motels, including apartment houses without provision for cooking by tenants[a]	22	2
Industrial commercial (loft) buildings	22	2
Lodge rooms	17	$1^{1}/_{2}$
Office buildings	39	$3^{1}/_{2}$[b]
Restaurants	22	2
Schools	33	3
Stores	33	3
Warehouses (storage)	3	$^{1}/_{4}$
In any of the preceding occupancies except one-family dwellings and individual dwelling units of two-family and multifamily dwellings:		
Assembly halls and auditoriums	11	1

Table 220.3(A) General Lighting Loads by Occupancy

Type of Occupancy	Unit Load	
	Volt-Amperes per Square Meter	Volt-Amperes per Sq[u] Foot
Halls, corridors, closets, stairways	6	1/2
Storage spaces	3	1/4

[a]See 220.3(B)(10).

[b]In addition, a unit load of 11 volt-amperes/m^2 or 1 volt-ampere/ft^2 shall be included for general-purpose receptacl[e] outlets where the actual number of general-purpose receptacle outlets is unknown.

(B) Other Loads — All Occupancies. In all occupancies, the minimum load for each outlet for general-use receptacles and outlets not used for general illumination shall not be less than that computed in 220.3(B)(1) through (11), the loads shown being based on nominal branch-circuit voltages.

Exception: The loads of outlets serving switchboards and switching frames in telephone exchanges shall be waived from the computations.

(1) Specific Appliances or Loads. An outlet for a specific appliance or other load not covered in (2) through (11) shall be computed based on the ampere rating of the appliance or load served.

(2) Electric Dryers and Household Electric Cooking Appliances. Load computations shall be permitted as specified in 220.18 for electric dryers and in 220.19 for electric ranges and other cooking appliances.

(3) Motor Loads. Outlets for motor loads shall be computed in accordance with the requirements in 430.22, 430.24, and 440.6.

(4) Recessed Luminaires (Lighting Fixtures). An outlet supplying recessed luminaire(s) [lighting fixture(s)] shall be computed based on the maximum volt-ampere rating of the equipment and lamps for which the luminaire(s) [fixture(s)] is rated.

Recessed luminaires are included in the 3 volt-amperes per square foot calculation used for dwellings if they are used for general lighting.

(5) Heavy-Duty Lampholders. Outlets for heavy-duty lampholders shall be computed at a minimum of 600 volt-amperes.

(6) Sign and Outline Lighting. Sign and outline lighting outlets shall be computed at a minimum of 1200 volt-amperes for each required branch circuit specified in 600.5(A).

Section 220.3(B)(6) assigns 1200 volt-amperes as a minimum circuit load for the signs and outline lighting outlets required by 600.5(A). If the specific load is known to be larger, then, according to 220.3(B)(1), the actual load is used.

(7) Show Windows. Show windows shall be computed in accordance with either of the following:

(1) The unit load per outlet as required in other provisions of this section

(2) At 200 volt-amperes per 300 mm (1 ft) of show window

The following two options are permitted for the load calculations for branch circuits serving show windows:

(1) 180 volt-amperes per receptacle according to 210.62, which requires one receptacle per 12 linear feet

(2) 200 volt-amperes per linear foot of show-window space

As shown in Exhibit 220.1, the linear-foot calculation method is permitted in lieu of the specified unit load per outlet for branch circuits serving show windows.

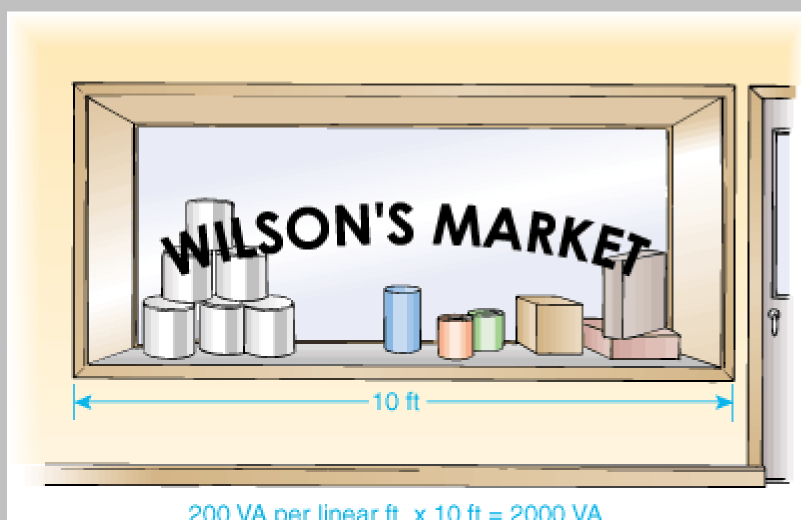

Exhibit 220.1 An example of the linear-foot load calculation for branch circuits serving a show window.

(8) Fixed Multioutlet Assemblies. Fixed multioutlet assemblies used in other than dwelling units or the guest rooms of hotels or motels shall be computed in accordance with (1) or (2). For the purposes of this section, the computation shall be permitted to be based on the portion that contains receptacle outlets.

(1) Where appliances are unlikely to be used simultaneously, each 1.5 m (5 ft) or fraction thereof of each separate and continuous length shall be considered as one outlet of not less than 180 volt-amperes.

(2) Where appliances are likely to be used simultaneously, each 300 mm (1 ft) or fraction thereof shall be considered as an outlet of not less than 180 volt-amperes.

Fixed multioutlet assemblies are commonly used in commercial and industrial locations. The use of multioutlet assemblies are divided into two broad areas. The first area of use is light use, which means that not all the cord-connected equipment is expected to be used at the same time, as noted in 220.3(B)(8)(1). An example of light use is a workbench area where one worker uses one electrical tool at a time. The second area of use is heavy use, which is characterized by all the cord-connected equipment generally operating at the same time, as noted in 220.3(B)(8)(2). An example of heavy use is a retail outlet displaying television sets, where most, if not all, sets are operating simultaneously.

As shown in Exhibit 220.2, the requirements of 220.3(B)(8) state that each 5 ft of a fixed multioutlet assembly must be considered as one outlet rated 180 volt-amperes and that, if appliances are likely to be used simultaneously, each 1 ft must be considered as one outlet rated 180 volt-amperes.

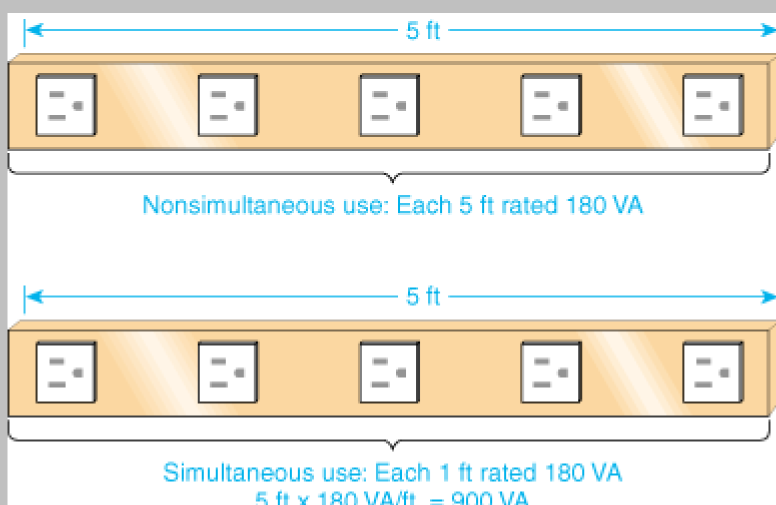

Exhibit 220.2 The requirements of 220.3(B)(8) as applied to fixed multioutlet assemblies.

(9) Receptacle Outlets. Except as covered in 220.3(B)(10), receptacle outlets shall be computed at not less than 180 volt-amperes for each single or for each multiple receptacle on one yoke. A single piece of equipment consisting of a multiple receptacle comprised of four or more receptacles shall be computed at not less than 90 volt-amperes per receptacle.

This provision shall not be applicable to the receptacle outlets specified in 210.11(C)(1) and (2).

As illustrated in Exhibit 220.3, the 180-volt-ampere load is applied to single and multiple receptacles mounted on a single yoke or strap, and a 360-volt-ampere load is applied to each receptacle that consists of four receptacles. These are considered receptacle outlets, in accordance with 220.3(B)(9). The receptacle outlets are not the lighting outlets installed for general illumination or the small-appliance branch circuits, as indicated in 220.3(B)(10). The receptacle load for outlets for general illumination in one- and two-family and multifamily dwellings and in guest rooms of hotels and motels is included in Table 220.3(A). The load requirement for the small-appliance branch circuits is 1500 volt-amperes per circuit, as described in 220.16(A).

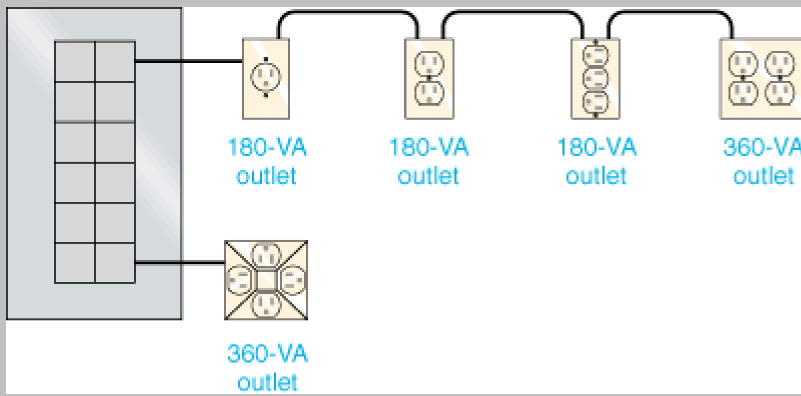

Exhibit 220.3 The 180-volt-ampere load requirement of 220.3(B)(9) as applied to single- and multiple-receptacle outlets on single straps and the 360-volt-ampere load applied to each receptacle that consists of four receptacles.

Note in Exhibit 220.3 that the last outlet of the top circuit consists of two duplex receptacles on separate straps. That outlet is calculated at 360 volt-amperes because each duplex receptacle is on one yolk. The multiple receptacle supplied from the bottom circuit that comprises four or more receptacles is calculated at 90 volt-amperes per receptacle (4 × 90 VA = 360 VA). For example, single-strap and multiple-receptacle devices are calculated as follows:

Device	Computed Load
Duplex receptacle	180 VA
Triplex receptacle	180 VA
Double duplex receptacle	360 VA (180 × 2)
Quad or four-plex-type receptacle	360 VA (90 × 4)

A load of 180 volt-amperes is not required to be considered for outlets supplying recessed lighting fixtures, lighting outlets for general illumination, and small-appliance branch circuits. To apply the 180-volt-ampere requirement in those cases would be unrealistic, because it would unnecessarily restrict the number of lighting or receptacle outlets on branch circuits in dwelling units. See the note below Table 220.3(A) that references 220.3(B)(10). This note indicates that the 180-volt-ampere requirement does not apply to most receptacle outlets in dwellings.

In Exhibit 220.4, the maximum number of outlets permitted on 15- and 20-ampere branch circuits is 10 and 13 outlets, respectively. This restriction does not apply to outlets connected to general lighting or small-appliance branch circuits in dwelling units.

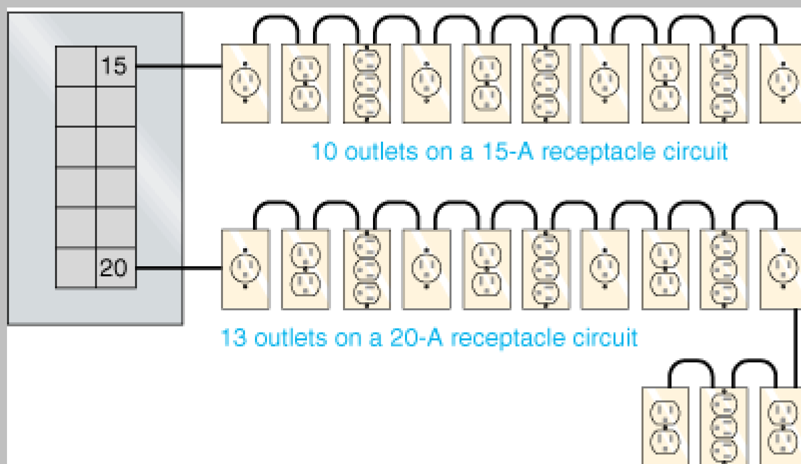

Exhibit 220.4 Maximum number of outlets permitted on 15- and 20-ampere branch circuits.

(10) Dwelling Occupancies. In one-family, two-family, and multifamily dwellings and in guest rooms of hotels and motels, the outlets specified in (1), (2), and (3) are included in the general lighting load calculations of 220.3(A). No additional load calculations shall be required for such outlets.

(1) All general-use receptacle outlets of 20-ampere rating or less, including receptacles connected to the circuits in 210.11(C)(3)

(2) The receptacle outlets specified in 210.52(E) and (G)

(3) The lighting outlets specified in 210.70(A) and (B)

(11) Other Outlets. Other outlets not covered in 220.3(B)(1) through (10) shall be computed based on 180 volt-amperes per outlet.

(C) Loads for Additions to Existing Installations.

(1) Dwelling Units. Loads added to an existing dwelling unit(s) shall comply with the following as applicable:

(1) Loads for structural additions to an existing dwelling unit or for a previously unwired portion of an existing dwelling unit, either of which exceeds 46.5 m^2 (500 ft^2), shall be computed in accordance with 220.3(A) and (B).

(2) Loads for new circuits or extended circuits in previously wired dwelling units shall be computed in accordance with either 220.3(A) or (B), as applicable.

(2) Other Than Dwelling Units. Loads for new circuits or extended circuits in other than dwelling units shall be computed in accordance with either 220.3(A) or (B), as applicable.

220.4 Maximum Loads.

The total load shall not exceed the rating of the branch circuit, and it shall not exceed the maximum loads specified in 220.4(A) through (C) under the conditions specified therein.

(A) Motor-Operated and Combination Loads. Where a circuit supplies only motor-operated loads, Article 430 shall apply. Where a circuit supplies only air-conditioning equipment, refrigerating equipment, or both, Article 440 shall apply. For circuits supplying loads consisting of motor-operated utilization equipment that is fastened in place and has a motor larger than $^1/_8$ hp in combination with other loads, the total computed load shall be based on 125 percent of the largest motor load plus the sum of the other loads.

(B) Inductive Lighting Loads. For circuits supplying lighting units that have ballasts, transformers, or autotransformers, the computed load shall be based on the total ampere ratings of such units and not on the total watts of the lamps.

(C) Range Loads. It shall be permissible to apply demand factors for range loads in accordance with Table 220.19, including Note 4.

II. Feeders and Services

220.10 General.

The computed load of a feeder or service shall not be less than the sum of the loads on the branch circuits supplied, as determined by Part I of this article, after any applicable demand factors permitted by Parts II, III, or IV have been applied.

FPN:See Examples D1(A) through D10 in Annex D. See 220.4(B) for the maximum load in amperes permitted for lighting units operating at less than 100 percent power factor.

In the example shown in Exhibit 220.5, each panel serves a computed load of 80 amperes. The main feeder is sized to carry the total computed load of 240 amperes (3 multiplied by 80 amperes). The feeder tap conductors from the meter enclosure to the panelboards are sized to supply a computed load of 80 amperes. The main feeder is not intended to be sized to carry 300 amperes based on the sum of the panelboards.

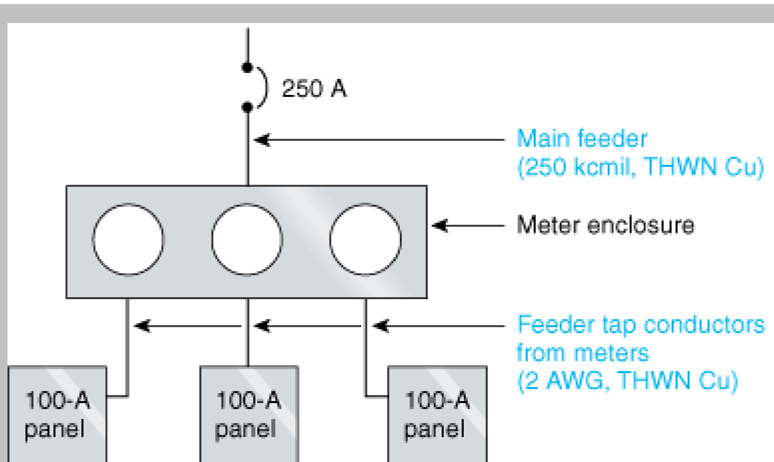

Exhibit 220.5 Feeder conductors sized in accordance with 220.10.

See Exhibit 230.13 for a similar example for service conductors. The ungrounded service conductors are no longer required to be sized for the sum of the main overcurrent device rating of 300 amperes. Service conductors are required to have sufficient ampacity to carry the loads computed in accordance with Article 220, with appropriate demand factors applied. See 230.23, 230.31, and 230.42 for specifics on size and rating of conductors.

Part II of Article 220 contains the requirements for calculating feeder and service loads. Part III provides optional methods for calculating feeder and service loads in dwelling units and multifamily dwellings.

Except as permitted in 240.4 and 240.6, the rating of the overcurrent device cannot exceed the final ampacity of the circuit conductors after all the correction and adjustment factors have been applied, such as for temperature or number of conductors.

Example

Determine the minimum-size overcurrent protective device and the minimum conductor size for a feeder circuit with the following characteristics:

- 3-phase, 4-wire feeder (full-size neutral)
- 125-ampere noncontinuous load
- 200-ampere continuous load
- 75°C overcurrent device terminal rating
- Type THWN insulated conductors
- Four current-carrying conductors in a raceway
- A major portion of the load is nonlinear

Solution

Step 1.

Select the feeder overcurrent protective device (OCPD) rating by first totaling the continuous and noncontinuous loads according to 215.3:

$$\begin{aligned}\text{OCPD rating} &= 125\% \text{ of continuous load} \\ &\quad + \text{noncontinuous load} \\ &= (200\ \text{A} \times 1.25) + 125\ \text{A} \\ &= 250\ \text{A} + 125\ \text{A} \\ &= 375\ \text{A}\end{aligned}$$

Using 240.4(B) and 240.6(A), adjust the minimum standard-size OCPD to 400 amperes.

Step 2.

Select the feeder conductor size before derating by first summing the continuous and noncontinuous loads according to 215.2(A)(1).

$$\begin{aligned}\begin{matrix}\text{Feeder size} \\ \text{(before derating)}\end{matrix} &= 125\% \text{ of continuous load} \\ &\quad + \text{noncontinuous load} \\ &= (200\ \text{A} \times 1.25) + 125\ \text{A} \\ &= 250\ \text{A} + 125\ \text{A} \\ &= 375\ \text{A}\end{aligned}$$

Using Table 310.16 and using the 75°C column (because of the overcurrent device terminal), the minimum-size Type THWN copper conductor that can supply a computed load of 375 amperes is 500-kcmil copper, which has an ampacity of 380 amperes.

Step 3.

Apply the derating factors to the feeder conductor size. Section 310.15(B)(4)(c) requires that the neutral conductor be counted as a current-carrying conductor because a major portion of the load consists of fluorescent and HID luminaires. Therefore, this feeder circuit consists of four current-carrying conductors in the same raceway. Section 310.15(B)(2) requires an 80 percent adjustment factor for four current-carrying conductors in the same raceway. According to Table 310.16, 500-kcmil, Type THWN conductors have an ampacity of 380 amperes. The adjustment factors are applied to this ampacity as follows:

$$\begin{aligned}\text{Adjusted ampacity} &= \text{table ampacity} \times \text{adjustment factor} \\ &= 380\ \text{A} \times 0.80 \\ &= 304\ \text{A}\end{aligned}$$

According to 240.4(B) and 240.6(A), a conductor with a computed ampacity of 304 amperes is not allowed to be protected by a 400-ampere overcurrent protective device. Therefore, the 500-kcmil, Type THWN copper conductor *cannot* be used.

Step 4.

Revise the feeder conductor selection and perform a check. The next standard size conductor listed in Table 310.16 is a 600-kcmil copper conductor in the 90°C column. If higher-temperature insulations are used, adjustment factors can be applied to the higher ampacity. Because Type THWN is a 75°C insulation, a 90°C Type THHN is selected. If a 600-kcmil Type THHN copper conductor is used, perform the check as follows. According to Table 310.16, a 600-kcmil conductor has an ampacity of 475 amperes in the Type THHN 90°C column:

$$\begin{aligned}\text{Adjusted ampacity} &= \text{table ampacity} \times \text{adjustment factor}\\ &= 475\ \text{A} \times 0.80\\ &= 380\ \text{A}\end{aligned}$$

A conductor with a computed ampacity of 380 amperes is allowed to be protected by a 400-ampere overcurrent protective device, in accordance with 240.4(B). However, because the overcurrent protective device terminations are rated 75°C, the load current cannot exceed the ampacity of a 600-kcmil conductor in the 75°C column of Table 310.16, which has a value of 420 amperes.

Step 5.

Evaluate the circuit. The calculation in Step 4 results in four 600-kcmil Type THHN copper conductors in one raceway, each with an ampacity of 380 amperes, supplying a 375-ampere continuous load, and protected by a 400-ampere overcurrent protective device. It is important to note here that a 90°C, 600-kcmil copper conductor with a final computed ampacity of 380 amperes is permitted to terminate on a 75°C-rated terminal, according to 110.14(C)(1)(b)(2).

220.11 General Lighting.

The demand factors specified in Table 220.11 shall apply to that portion of the total branch-circuit load computed for general illumination. They shall not be applied in determining the number of branch circuits for general illumination.

Table 220.11 Lighting Load Demand Factors

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (Percent)
Dwelling units	First 3000 or less at	100
	From 3001 to 120,000 at	35
	Remainder over 120,000 at	25
Hospitals*	First 50,000 or less at	40
	Remainder over 50,000 at	20

Table 220.11 Lighting Load Demand Factors

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (Percent)
Hotels and motels, including apartment houses without provision for cooking by tenants*	First 20,000 or less at	50
	Remainder over 100,000 at	30
Warehouses (storage)	First 12,500 or less at	100
	Remainder over 12,500 at	50
All others	Total volt-amperes	100

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

220.12 Show-Window and Track Lighting.

(A) Show Windows. For show-window lighting, a load of not less than 660 volt-amperes/linear meter or 200 volt-amperes/linear foot shall be included for a show window, measured horizontally along its base.

FPN:See 220.3(B)(7) for branch circuits supplying show windows.

The 200-volt-ampere calculation for each linear foot of a show window is required to determine the *feeder* load. See the commentary following 220.3(B)(7) for load calculations for branch circuits in show windows.

(B) Track Lighting. For track lighting in other than dwelling units or guest rooms of hotels or motels, an additional load of 150 volt-amperes shall be included for every 600 mm (2 ft) of lighting track or fraction thereof. Where multicircuit track is installed, the load shall be considered to be divided equally between the track circuits.

Example

A lighting plan shows 62.5 linear ft of single-circuit track lighting for a small department store featuring clothing. Because the actual track lighting fixtures are owner supplied, neither the quantity of track lighting fixtures or the lamp size is specified. What is the minimum calculated load associated with the track lighting that must be added to the service or feeder supplying this store?

Solution

According to 220.12(B), the minimum calculated load to be added to the service or feeder supplying this track light installation is calculated as follows:

$$\frac{62.5\text{ ft}}{2\text{ ft}} = 31.25\text{, rounded up to } 32$$
$$32 \times 150\text{ VA} = 4800\text{ VA}$$

Thus, the minimum load that must be added to the service or feeder calculation is 4800 volt-amperes.

It is important to note that the branch circuits supplying this installation are covered in 410.101(B). For the track lighting branch-circuit load, the maximum load on the track cannot exceed the rating of the branch circuit supplying the track. Also, the track must be supplied by a branch circuit that has a rating not exceeding the rating of the track. The track length does not enter into the branch-circuit calculation.

Section 220.12(B) is not intended to limit the number of feet of track on a single branch circuit, nor is it intended to limit the number of fixtures on an individual track. Rather, 220.12(B) is meant to be used solely for load calculations of feeders and services.

220.13 Receptacle Loads — Nondwelling Units.

In other than dwelling units, receptacle loads computed at not more than 180 volt-amperes per outlet in accordance with 220.3(B)(9) and fixed multioutlet assemblies computed in accordance with 220.3(B)(8) shall be permitted to be added to the lighting loads and made subject to the demand factors given in Table 220.11, or they shall be permitted to be made subject to the demand factors given in Table 220.13.

Table 220.13 Demand Factors for Nondwelling Receptacle Loads

Portion of Receptacle Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (Percent)
First 10 kVA or less at	100
Remainder over 10 kVA at	50

Section 220.13 permits receptacle loads, calculated at not more than 180 volt-amperes per strap, to be computed by either of the following two methods:

(1) The receptacle loads are added to the lighting load. The demand factors in Table 220.11 are then applied to the combined load.

(2) The receptacle loads are calculated (without the lighting load) with demand factors from Table 220.13 applied.

220.14 Motors.

Motor loads shall be computed in accordance with 430.24, 430.25, and 430.26 and with 440.6 for hermetic refrigerant motor compressors.

220.15 Fixed Electric Space Heating.

Fixed electric space heating loads shall be computed at 100 percent of the total connected load; however, in no case shall a feeder or service load current rating be less than the rating of the largest branch circuit supplied.

Exception: Where reduced loading of the conductors results from units operating on duty-cycle, intermittently, or from all units not operating at the same time, the authority having jurisdiction may grant permission for feeder and service conductors to have an ampacity less than 100 percent, provided the conductors have an ampacity for the load so determined.

220.16 Small Appliance and Laundry Loads — Dwelling Unit.

(A) Small Appliance Circuit Load. In each dwelling unit, the load shall be computed at 1500 volt-amperes for each 2-wire small-appliance branch circuit required by 210.11(C)(1). Where the load is subdivided through two or more feeders, the computed load for each shall include not less than 1500 volt-amperes for each 2-wire small-appliance branch circuit. These loads shall be permitted to be included with the general lighting load and subjected to the demand factors provided in Table 220.11.

Exception: The individual branch circuit permitted by 210.52(B)(1), Exception No. 2, shall be permitted to be excluded from the calculation required by 220.16.

See the commentary following 210.52(B) regarding required receptacle outlets for small-appliance branch circuits.

(B) Laundry Circuit Load. A load of not less than 1500 volt-amperes shall be included for each 2-wire laundry branch circuit installed as required by 210.11(C)(2). This load shall be permitted to be included with the general lighting load and subjected to the demand factors provided in Table 220.11.

In each dwelling unit, the feeder load is required to be calculated at 1500 volt-amperes for each of the two or more (2-wire) small-appliance branch circuits and at 1500 volt-amperes for each (2-wire) laundry branch circuit. These loads are permitted to be totaled and then added to the general lighting load. The total load (i.e., small appliance, laundry, and general lighting) is subjected to the demand factors provided in Table 220.11.

220.17 Appliance Load — Dwelling Unit(s).

It shall be permissible to apply a demand factor of 75 percent to the nameplate rating load of four or more appliances fastened in place, other than electric ranges, clothes dryers, space-heating equipment, or air-conditioning equipment, that are served by the same feeder or service in a one-family, two-family, or multifamily dwelling.

For appliances fastened in place (other than ranges, clothes dryers, and space-heating and air-conditioning equipment), feeder capacity must be provided for the sum of these loads, and for a total load of four or more such appliances, a demand factor of 75 percent may be applied. See Table 430.148 for the full-load current, in amperes, for single-phase ac motors, in accordance with 220.14.

Example

Determine the feeder capacity needed for a 120/240-volt fastened-in-place appliance load in a dwelling unit for the following:

Appliance	Rating	Load
Water heater	4000 W, 240 V	4000 VA
Kitchen disposal	1/2 hp, 120 V	1176 VA
Dishwasher	1200 W, 120 V	1200 VA
Furnace motor	1/4 hp, 120 V	696 VA
Attic fan	1/4 hp, 120 V	696 VA
Water pump	1/2 hp, 240 V	1176 VA

Solution

Step 1.

Calculate the total of the six fastened-in-place appliances:

$$\begin{aligned}\text{Total load} &= 4000\text{ VA} + 1176\text{ VA} + 1200\text{ VA} \\ &\quad + 696\text{ VA} + 696\text{ VA} + 1176\text{ VA} \\ &= 8944\text{ VA}\end{aligned}$$

Step 2.

Because the load is for more than four appliances, apply a demand factor of 75 percent:

$$8944\text{ VA} \times 0.75 = 6708\text{ VA}$$

Thus, 6708 volt-amperes is the load to be added to the other determined loads when calculating the size of service and feeder conductors.

220.18 Electric Clothes Dryers — Dwelling Unit(s).

The load for household electric clothes dryers in a dwelling unit(s) shall be 5000 watts (volt-amperes) or the nameplate rating, whichever is larger, for each dryer served. The use of the demand factors in Table 220.18 shall be permitted. Where two or more single-phase dryers are supplied by a 3-phase, 4-wire feeder or service, the total load shall be computed on the basis of twice the maximum number connected between any two phases.

Table 220.18 Demand Factors for Household Electric Clothes Dryers

Number of Dryers	Demand Factor (Percent)
1–4	100%
5	85%
6	75%
7	65%
8	60%
9	55%
10	50%
11	47%
12–22	% = 47 – (number of dryers - 11)
23	35%
24–42	% = 35 – [0.5 × (number of dryers - 23)]
43 and over	25%

The exact method of calculation presented in Table 220.18 was revised for the 2002 *Code* to produce a more accurate load for all quantities of dryers. To compute the load of household electric dryers, 220.18 specifies a minimum demand of 5 kVA for the calculation of feeder conductors. If the nameplate rating is known and exceeds 5 kW, the larger rating is applied.

220.19 Electric Ranges and Other Cooking Appliances — Dwelling Unit(s).

The demand load for household electric ranges, wall-mounted ovens, counter-mounted cooking units, and other household cooking appliances individually rated in excess of $1^3/_4$ kW shall be permitted to be computed in accordance with Table 220.19. Kilovolt-amperes (kVA) shall be considered equivalent to kilowatts (kW) for loads computed under this section.

Where two or more single-phase ranges are supplied by a 3-phase, 4-wire feeder or service, the total load shall be computed on the basis of twice the maximum number connected between any two phases.

Table 220.19 Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^3/_4$ kW] (Column C to be used in all cases except as otherwise permitted in Note 3.)

Where two or more single-phase ranges are supplied by a 3-phase, 4-wire feeder or service, the total load shall be computed on the basis of twice the maximum number connected between any two phases.

Table 220.19 Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^{3}/_{4}$ kW I
(Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (Percent) (See Notes) Column A (Less than $3^{1}/_{2}$ kW Rating)	Column B ($3^{1}/_{2}$ kW to $8^{3}/_{4}$ kW Rating)	Column C Maximun (kW) (See Notes) (N kW Rating)
1	80	80	8
2	75	65	11
3	70	55	14
4	66	50	17
5	62	45	20
6	59	43	21
7	56	40	23
8	53	36	23
9	51	35	24
10	49	34	25
11	47	32	26
12	45	32	27
13	43	32	28
14	41	32	29
15	40	32	30
16	39	28	31
17	38	28	32
18	37	28	33
19	36	28	34
20	25	28	35
21	34	26	36
22	33	26	37
23	32	26	38
24	31	26	39
25	30	26	40
26–30	30	24	
31–40	30	22	15 kW + 1 kW for ea
41–50	30	20	
51–60	30	18	
61 and over	30	16	25 kW + $^{3}/_{4}$ kW for e

Table 220.19 Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^{3}/_{4}$ kW I
(Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (Percent) (See Notes)		Column C Maximun (kW) (See Notes) (N kW Rating)
	Column A (Less than $3^{1}/_{2}$ kW Rating)	Column B ($3^{1}/_{2}$ kW to $8^{3}/_{4}$ kW Rating)	

1. Over 12 kW through 27 kW ranges all of same rating. For ranges individually rated more than 12 kW but not mc 27 kW, the maximum demand in Column C shall be increased 5 percent for each additional kilowatt of rating or ma fraction thereof by which the rating of individual ranges exceeds 12 kW.

For household electric ranges and other cooking appliances, the size of the conductors must be determined by the rating of the range. According to Table 220.19, for one range rated 12 kW or l maximum demand load is 8 kW (8 kVA per 220.19), and 8 AWG copper conductors with 60°C i would suffice. Note that 210.19(A)(3) does not permit the branch-circuit rating of a circuit suppl household ranges with a nameplate rating of $8^{3}/_{4}$-kW to be less than 40 amperes.

2. Over 8¾ kW through 27 kW ranges of unequal ratings. For ranges individually rated more than 8¾ kW and of di ratings, but none exceeding 27 kW, an average value of rating shall be computed by adding together the ratings of a ranges to obtain the total connected load (using 12 kW for any range rated less than 12 kW) and dividing by the tot number of ranges. Then the maximum demand in Column C shall be increased 5 percent for each kilowatt or major fraction thereof by which this average value exceeds 12 kW.

Note 2 to Table 220.19 provides for ranges larger than $8^{3}/_{4}$ kW. Note 4 covers installations where circuit supplies multiple cooking components, which are combined and treated as a single range.

3. Over 1¾ kW through 8¾ kW. In lieu of the method provided in Column C, it shall be permissible to add the nam ratings of all household cooking appliances rated more than 1¾ kW but not more than 8¾ kW and multiply the sum demand factors specified in Column A or B for the given number of appliances. Where the rating of cooking applia falls under both Column A and Column B, the demand factors for each column shall be applied to the appliances fo column, and the results added together.

The branch-circuit load for one range is permitted to be computed by using either the nameplate r the appliance or Table 220.19. If a single branch circuit supplies a counter-mounted cooking unit more than two wall-mounted ovens, all of which are located in the same room, the nameplate rati these appliances can be added together and the total treated as the equivalent of one range, accord Note 4 of Table 220.19.

The branch-circuit load for one range is permitted to be computed by using either the nameplate r

Table 220.19 Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^{3}/_{4}$ kW I (Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (Percent) (See Notes)		Column C Maximun (kW) (See Notes) (No kW Rating)
	Column A (Less than $3^{1}/_{2}$ kW Rating)	Column B ($3^{1}/_{2}$ kW to $8^{3}/_{4}$ kW Rating)	

the appliance or Table 220.19. If a single branch circuit supplies a counter-mounted cooking unit more than two wall-mounted ovens, all of which are located in the same room, the nameplate rati these appliances can be added together and the total treated as the equivalent of one range, accord Note 4 of Table 220.19.

Example

Calculate the load for a single branch circuit that supplies the following cooking units:

One counter-mounted cooking unit, with rating of 8 kW

One wall-mounted oven, with rating of 7 kW

A second wall-mounted oven, with rating of 6 kW

Solution

Step 1.

The combined cooking appliances can be treated as one range according to Note 4 of Table 220.1 Table 220.19, find the maximum demand for one range not over 12 kW, which is 8 kW (from Co C).

Step 2.

According to Note 1 in Table 220.19, for ranges that are over 12 kW but not more than 27 kW, th maximum demand in Column C (8 kW) is increased 5 percent for each kW that exceeds 12 kW. Determine the additional kilowatts:

$$\text{Combined unit rating} = 8\ \text{kW} + 7\ \text{kW} + 6\ \text{kW} = 21\ \text{kW}$$
$$\text{Additional kW} = 21\ \text{kW} - 12\ \text{kW} = 9\ \text{kW}$$

Table 220.19 Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^3/_4$ kW

(Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (Percent) (See Notes)		Column C Maximum (kW) (See Notes) (N… kW Rating)
	Column A (Less than $3^1/_2$ kW Rating)	Column B ($3^1/_2$ kW to $8^3/_4$ kW Rating)	

Step 3.

Calculate by how much the maximum load in Column C in Table 220.19 must be increased for th combined appliances:

$$\text{Increase} = 5\% \text{ per kW} \times 9 \text{ kW} = 45\%$$
$$= 0.45 \times 8 \text{ kW} = 3.6 \text{ kW}$$

Step 4.

Calculate the total load in amperes, as follows:

$$\text{Total Load} = 8 \text{ kW} + 3.6 \text{ kW} = 11.6 \text{ kW}$$
$$= 11.6 \text{ kW} = 11{,}600 \text{ W} = 11{,}600 \text{ VA}$$
$$= \frac{11{,}600 \text{ VA}}{240 \text{ V}}$$
$$= 48.3 \text{ A}$$

4. Branch-Circuit Load. It shall be permissible to compute the branch-circuit load for one range in accordance with 220.19. The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the name rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mo ovens, all supplied from a single branch circuit and located in the same room, shall be computed by adding the nam rating of the individual appliances and treating this total as equivalent to one range.

5. This table also applies to household cooking appliances rated over $1^3/_4$ kW and used in instructional programs.

The nameplate ratings of all household cooking appliances rated more than $1^3/_4$ kW but not more $8^3/_4$ kW may be added together and the sum multiplied by the demand factors specified in Colum of Table 220.19 for the given number of appliances. For feeder demand factors for other than dw units—that is, commercial electric cooking equipment, dishwasher booster heaters, water heaters on—see Table 220.20.

The demand factors of this *Code* are based on the diversified use of appliances, because it is unli all appliances will be used simultaneously or that all cooking units and the oven of a range will b maximum heat for any length of time.

It shall be permissible to compute the load for commercial electric cooking equipment, dishwasher booster heaters, water heaters, and other kitchen equipment in accordance with Table 220.20. These demand factors shall be applied to all equipment that has either thermostatic control or intermittent use as kitchen equipment. They shall not apply to space-heating, ventilating, or air-conditioning equipment.

However, in no case shall the feeder or service demand be less than the sum of the largest two kitchen equipment loads.

Table 220.20 Demand Factors for Kitchen Equipment — Other Than Dwelling Unit(s)

Number of Units of Equipment	Demand Factor (Percent)
1	100
2	100
3	90
4	80
5	70
6 and over	65

220.21 Noncoincident Loads.

Where it is unlikely that two or more noncoincident loads will be in use simultaneously, it shall be permissible to use only the largest load(s) that will be used at one time, in computing the total load of a feeder or service.

220.22 Feeder or Service Neutral Load.

The feeder or service neutral load shall be the maximum unbalance of the load determined by this article. The maximum unbalanced load shall be the maximum net computed load between the neutral and any one ungrounded conductor, except that the load thus obtained shall be multiplied by 140 percent for 3-wire, 2-phase or 5-wire, 2-phase systems. For a feeder or service supplying household electric ranges, wall-mounted ovens, counter-mounted cooking units, and electric dryers, the maximum unbalanced load shall be considered as 70 percent of the load on the ungrounded conductors, as determined in accordance with Table 220.19 for ranges and Table 220.18 for dryers. For 3-wire dc or single-phase ac; 4-wire, 3-phase; 3-wire, 2-phase; or 5-wire, 2-phase systems, a further demand factor of 70 percent shall be permitted for 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 that consists of nonlinear loads supplied from a 4-wire, wye-connected, 3-phase system. There shall be no reduction in the capacity of the grounded conductor of a 3-wire circuit consisting of two phase wires and the neutral of a

4-wire, 3-phase, wye-connected system.

FPN No. 1:See Examples D1(A), D1(B), D2(B), D4(A), and D5(A) in Annex D.

FPN No. 2:A 3-phase, 4-wire, wye-connected power system used to supply power to nonlinear loads may necessitate that the power system design allow for the possibility of high harmonic neutral currents.

Section 220.22 describes the basis for calculating the neutral load of feeders or services as the maximum unbalanced load that can occur between the neutral and any other ungrounded conductor.

For a household electric range or clothes dryer, the maximum unbalanced load may be assumed to be 70 percent, so the neutral may be sized on that basis. Although 220.22 permits the reduction of the feeder neutral conductor size under specific conditions of use, the last two sentences, revised for the 2002 *Code*, cite two specific cases that would prohibit reducing a neutral or grounded conductor of a feeder.

If the system also supplies nonlinear loads such as electric-discharge lighting, including fluorescent and HID, or data-processing or similar equipment, the neutral is considered a current-carrying conductor if the load of the electric-discharge lighting, data-processing, or similar equipment on the feeder neutral consists of more than half the total load. Electric-discharge lighting and data-processing equipment may have harmonic currents in the neutral that may exceed the load current in the ungrounded conductors. It would be appropriate to require a full-size or larger feeder neutral conductor, depending on the total harmonic distortion contributed by the equipment to be supplied (see 220.22, FPN No. 2).

In some instances, the neutral current may exceed the current in the phase conductors. See the commentary following 310.15(B)(4)(c) regarding neutral conductor ampacity.

III. Optional Calculations for Computing Feeder and Service Loads

220.30 Optional Calculation — Dwelling Unit.

(A) Feeder and Service Load. For a dwelling unit having the total connected load served by a single 3-wire, 120/240-volt or 208Y/120-volt set of service or feeder conductors with an ampacity of 100 or greater, it shall be permissible to compute the feeder and service loads in accordance with this section instead of the method specified in Part II of this article. The calculated load shall be the result of adding the loads from 220.30(B) and (C). Feeder and service-entrance conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by 220.22.

The optional method given in 220.30 applies to a single dwelling unit, whether it is a separate building or located in a multifamily dwelling. The optional calculation permitted by 220.30 may be used only if the service-entrance or feeder conductors have an ampacity of at least 100 amperes. See Article 100 for the definition of *dwelling unit*.

Examples of the optional calculation for a dwelling unit are given in Examples D2(a), D2(b), D2(c), and D4(b) of Annex D.

(B) General Loads. The general calculated load shall be not less than 100 percent of the first 10 kVA plus 40 percent of the remainder of the following loads:

(1) 1500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit specified in 220.16.

(2) 33 volt-amperes/m^2 or 3 volt-amperes/ft^2 for general lighting and general-use receptacles. The floor area for each floor shall be computed from the outside dimensions of the dwelling unit. The computed floor area shall not include open porches, garages, or unused or unfinished spaces not adaptable for future use.

(3) The nameplate rating of all appliances that are fastened in place, permanently connected, or located to be on a specific circuit, ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and water heaters.

Section 220.30(B)(3) includes appliances that may not be fastened in place but may be permanently connected or on a specific circuit, such as clothes dryers, dishwashers, and freezers.

(4) The nameplate ampere or kVA rating of all motors and of all low-power-factor loads.

(C) Heating and Air-Conditioning Load. The largest of the following six selections (load in kVA) shall be included:

(1) 100 percent of the nameplate rating(s) of the air conditioning and cooling.

(2) 100 percent of the nameplate ratings of the heat pump compressors and supplemental heating unless the controller prevents the compressor and supplemental heating from operating at the same time.

(3) 100 percent of the nameplate ratings of electric thermal storage and other heating systems where the usual load is expected to be continuous at the full nameplate value. Systems qualifying under this selection shall not be calculated under any other selection in 220.30(C).

(4) 65 percent of the nameplate rating(s) of the central electric space heating, including integral supplemental heating in heat pumps where the controller prevents the compressor and supplemental heating from operating at the same time.

(5) 65 percent of the nameplate rating(s) of electric space heating if less than four separately controlled units.

(6) 40 percent of the nameplate rating(s) of electric space heating if four or more separately controlled units.

Section 220.21 states that for loads that do not operate simultaneously, the largest load being considered is used. In concert with 220.21, 220.30(C) requires that only the largest of the six choices needs to be included in the feeder or service calculation. Examples of calculations using air conditioning and heating are found in Annex D, Examples D2(b) and D3(c).

220.31 Optional Calculations for Additional Loads in an Existing Dwelling Unit.

This section shall be permitted to be used to determine if the existing service or feeder is of sufficient capacity to serve additional loads. Where the dwelling unit is served by a 120/240-volt or 208Y/120-volt, 3-wire service, it shall be permissible to compute the total load in accordance with 220.31(A) or (B).

(A) Where Additional Air-Conditioning Equipment or Electric Space-Heating Equipment Is Not to Be Installed. The following formula shall be used for existing and additional new loads.

Load (kVa)	Percent of Load
First 8 kVA of load at	100
Remainder of load at	40

Load calculations shall include the following:

(1) General lighting and general-use receptacles at 33 volt-amperes/m^2 or 3 volt-amperes/ft^2 as determined by 220.3(A)

(2) 1500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit specified in 220.16

(3) Household range(s), wall-mounted oven(s), and counter-mounted cooking unit(s)

(4) All other appliances that are permanently connected, fastened in place, or connected to a dedicated circuit, at nameplate rating

(B) Where Additional Air-Conditioning Equipment or Electric Space-Heating Equipment Is to Be Installed. The following formula shall be used for existing and additional new loads. The larger connected load of air-conditioning or space-heating, but not both, shall be used.

Air-conditioning equipment	100
Central electric space heating	100
Less than four separately controlled space-heating units	100
First 8 kVA of all other loads	100
Remainder of all other loads	40

Other loads shall include the following:

(1) General lighting and general-use receptacles at 33 volt-amperes/m^2 or 3 volt-amperes/ft^2 as determined by 220.3(A)

(2) 1500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit specified in 220.16

(3) Household range(s), wall-mounted oven(s), and counter-mounted cooking unit(s)

(4) All other appliances that are permanently connected, fastened in place, or connected to a dedicated circuit, including four or more separately controlled space-heating units, at nameplate rating

The optional method described in Section 220.31(A) or (B) allows an additional load to be supplied by an existing service.

Example

An existing dwelling unit is served by a 100-ampere service. An additional load of a single 5 kVA, 240-volt air conditioning unit is to be installed. Because the exiting load does not contain heating or air-conditioning equipment, the existing load is calculated according to 220.31(A). The load of the existing dwelling unit consists of the following:

General lighting, 24 ft × 40 ft = 960 ft^2 × 3 VA per ft^2	2,880 VA
Small-appliance circuits (3 × 1500 VA)	4,500 VA
Laundry circuit at 1500 VA	1,500 VA
Electric range rated 10.5 kW	10,500 VA
Electric water heater rated 3.0 kW	3,000 VA
Total existing load	22,380 VA

Step 1.

Following the requirements of 220.31(A), calculate the existing dwelling unit load before adding any equipment:

First 8 kVA of load at 100%	8,000 VA
Remainder of load at 40% (22,380 – 8,000) = 14,380 × 40%	5,752 VA
Total load (without air-conditioning equipment)	13,752 VA
13,752 VA ÷ 240 V	57.3 amps

Step 2.

Prepare a list of the existing and new loads of the dwelling unit.

General lighting, 24 ft × 40 ft = 960 ft^2 × 3 VA per ft^2	2,880 VA
Small-appliance circuits (3 × 1500 VA)	4,500 VA
Laundry circuit at 1500 VA	1,500 VA

Electric range rated 10.5 kW	10,500 VA
Electric water heater rated 3.0 kW	3,000 VA
Added air-conditioning equipment	5,000 VA
Total new load	27,380 VA

Step 3.

Following the requirements of 220.31(B), calculate the dwelling unit total load after adding any new equipment.

First 8 kVA of other load at 100%	8,000 VA
Remainder of other load at 40% (22,380 – 8,000) = 14,380 × 40%	5,752 VA
100% of air-conditioning equipment	5,000 VA
Total load (with added air-conditioning equipment)	18,752 VA
18,752 VA ÷ 240 V	78.13 amps

The additional load contributed by the added 5-kVA air conditioning does not exceed the allowable load permitted on a 100-ampere service.

220.32 Optional Calculation — Multifamily Dwelling.

(A) Feeder or Service Load. It shall be permissible to compute the load of a feeder or service that supplies more than two dwelling units of a multifamily dwelling in accordance with Table 220.32 instead of Part II of this article where all the following conditions are met:

(1) No dwelling unit is supplied by more than one feeder.

(2) Each dwelling unit is equipped with electric cooking equipment.

The method of load calculation under 220.32 is optional and applies only where one service or feeder supplies the entire load of a dwelling unit. If all the stated conditions prevail, the optional calculations in 220.32 may be used instead of those in Part II of Article 220.

Exception: When the computed load for multifamily dwellings without electric cooking in Part II of this article exceeds that computed under Part III for the identical load plus electric cooking (based on 8 kW per unit), the lesser of the two loads shall be permitted to be used.

Section 220.32(A)(2) requires that each dwelling unit be equipped with electric cooking equipment in order to use the load calculation method found in 220.32(A). The exception to 220.32(A)(2) permits load calculation for dwelling units that do not have electric cooking equipment by calculating a simulated electric cooking equipment load of 8 kW per unit and selecting the lesser of the two loads.

(3) Each dwelling unit is equipped with either electric space heating, air conditioning, or both. Feeders and service conductors whose demand load is determined by this optional

calculation shall be permitted to have the neutral load determined by 220.22.

(B) House Loads. House loads shall be computed in accordance with Part II of this article and shall be in addition to the dwelling unit loads computed in accordance with Table 220.32.

Table 220.32 Optional Calculations — Demand Factors for Three or More Multifamily Dwelling Units

Number of Dwelling Units	Demand Factor (Percent)
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 and over	23

(C) Connected Loads. The computed load to which the demand factors of Table 220.32 apply shall include the following:

(1) 1500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit specified in 220.16.

(2) 33 volt-amperes/m² or 3 volt-amperes/ft² for general lighting and general-use receptacles.

(3) The nameplate rating of all appliances that are fastened in place, permanently connected or located to be on a specific circuit, ranges, wall-mounted ovens, counter-mounted

cooking units, clothes dryers, water heaters, and space heaters. If water heater elements are interlocked so that all elements cannot be used at the same time, the maximum possible load shall be considered the nameplate load.

(4) The nameplate ampere or kilovolt-ampere rating of all motors and of all low-power-factor loads.

(5) The larger of the air-conditioning load or the space-heating load.

220.33 Optional Calculation — Two Dwelling Units.

Where two dwelling units are supplied by a single feeder and the computed load under Part II of this article exceeds that for three identical units computed under 220.32, the lesser of the two loads shall be permitted to be used.

220.34 Optional Method — Schools.

The calculation of a feeder or service load for schools shall be permitted in accordance with Table 220.34 in lieu of Part II of this article where equipped with electric space heating, air conditioning, or both. The connected load to which the demand factors of Table 220.34 apply shall include all of the interior and exterior lighting, power, water heating, cooking, other loads, and the larger of the air-conditioning load or space-heating load within the building or structure.

Feeders and service-entrance conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by 220.22. Where the building or structure load is calculated by this optional method, feeders within the building or structure shall have ampacity as permitted in Part II of this article; however, the ampacity of an individual feeder shall not be required to be larger than the ampacity for the entire building.

This section shall not apply to portable classroom buildings.

Many schools add small, portable classroom buildings. The air-conditioning load in these portable classrooms must comply with Article 440, and the lighting load must be considered continuous. The demand factors in Table 220.34 do not apply to portable classrooms, because those demand factors would decrease the feeder or service size to below that required for the connected continuous load.

Table 220.34 Optional Method — Demand Factors for Feeders and Service-Entrance Conductors for Schools

Connected Load	Demand Factor (Percent)
First 33 VA/m^2 (3 VA/ft^2) at	100

Table 220.34 Optional Method — Demand Factors for Feeders and Service-Entrance Conductors for Schools

Connected Load	Demand Factor (Percent)
Plus	
Over 33 to 220 VA/m^2 (3 to 20 VA/ft^2) at	75
Plus	
Remainder over 220 VA/m^2 (20 VA/ft^2) at	25

220.35 Optional Calculations for Determining Existing Loads.

The calculation of a feeder or service load for existing installations shall be permitted to use actual maximum demand to determine the existing load under the following conditions:

(1) The maximum demand data is available for a 1-year period.

Exception: If the maximum demand data for a 1-year period is not available, the calculated load shall be permitted to be based on the maximum demand (measure of average power demand over a 15-minute period) continuously recorded over a minimum 30-day period using a recording ammeter or power meter connected to the highest loaded phase of the feeder or service, based on the initial loading at the start of the recording. The recording shall reflect the maximum demand of the feeder or service by being taken when the building or space is occupied and shall include by measurement or calculation the larger of the heating or cooling equipment load, and other loads that may be periodic in nature due to seasonal or similar conditions.

(2) The maximum demand at 125 percent plus the new load does not exceed the ampacity of the feeder or rating of the service.

(3) The feeder has overcurrent protection in accordance with 240.4, and the service has overload protection in accordance with 230.90.

Additional loads may be connected to existing services and feeders under the following conditions:

(1) The maximum demand kVA data for a minimum one-year period (or the 30-day alternate method from the exception) is available

(2) The installation complies with 220.35(2) and (3).

220.36 Optional Calculation — New Restaurants.

Calculation of a service or feeder load, where the feeder serves the total load, for a new restaurant shall be permitted in accordance with Table 220.36 in lieu of Part II of this article.

The overload protection of the service conductors shall be in accordance with 230.90 and 240.4.

Feeder conductors shall not be required to be of greater ampacity than the service conductors.

Service or feeder conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by 220.22.

Section 220.36 recognizes the effects of load diversity that are typical of restaurant occupancies. It also recognizes the amount of continuous loads as a percentage of the total connected load. The exact method of calculation presented in Table 220.36 was revised for the 2002 *Code* to more accurately reflect the original load study data.

The National Restaurant Association, the Edison Electric Institute, and the Electric Power Research Institute based the data for the change in 220.36 on load studies of 262 restaurants. These studies show that the demand factors were lower for restaurants with larger connected loads. Based on this information, it was determined that demand factors for restaurant loads are appropriate.

When using the optional method found in 220.36, it is important to notice that first, all loads are added together, even heating and air conditioning, and then the appropriate demand load is calculated from Table 220.36. The service or feeder size is calculated after application of the demand load factor.

Example 1

A new, all-electric restaurant has a total connected load of 348 kVA at 208Y/120 volts. Using Table 220.36, calculate the demand load and determine the size of the service-entrance conductors and the maximum-size overcurrent device for the service.

Solution

Step 1.

Use the value in Table 220.36 for a connected load of 348 kVA (Row 3, Column 2) to calculate the demand load for an all electric restaurant.

$$\begin{aligned}\text{Demand load} &= 50\% \text{ of amount over } 325 \text{ kVA} + 172.5 \text{ kVA} \\ &= 0.50 \times (348 \text{ kVA} - 325 \text{ kVA}) + 172.5 \text{ kVA} \\ &= (0.50 \times 23) + 172.5 \\ &= 11.5 + 172.5 \\ &= 184 \text{ kVA}\end{aligned}$$

Step 2.

Calculate the service size using the calculated demand load in Step 1.

$$\text{Service size} = \frac{\text{kVA}_{\text{Demand load}} \times 1000}{\text{voltage} \times \sqrt{3}}$$
$$= \frac{184\ \text{kVA} \times 1000}{208\ \text{V} \times \sqrt{3}}$$
$$= 510.7 \text{ or } 511\ \text{A}$$

Step 3.

Determine the size of the overcurrent device. The next larger standard-size overcurrent device is 600 amperes. The minimum size of the conductors must be adequate to handle the load, but 240.4(B) permits the next larger standard-rated overcurrent device to be used.

Example 2

A new restaurant has gas cooking appliances plus a total connected electrical load of 348 kVA at 208Y/120 volts. Calculate the demand load using Table 220.36 and the service size. Then determine the maximum-size overcurrent device for the service.

Solution

Step 1.

Calculate the demand load for a new restaurant using the value in Table 220.36 for a connected load of 348 kVA (Column 3, Row 3) as follows:

$$\text{Demand load} = 45\% \text{ of amount over } 325\ \text{kVA} + 262.5\ \text{kVA}$$
$$= 0.45 \times (348 - 325) + 262.5$$
$$= (0.45 \times 23) + 262.5$$
$$= 10.35 + 262.5$$
$$= 272.85\ \text{kVA}$$

Step 2.

Calculate the service size using the calculated demand load in Step 1.

$$\text{Service size} = \frac{\text{kVA}_{\text{Demand load}} \times 1000}{\text{voltage} \times \sqrt{3}}$$
$$= \frac{272.85\ \text{kVA} \times 1000}{208\ \text{V} \times \sqrt{3}}$$
$$= 757.36 \text{ or } 757\ \text{A}$$

Step 3.

Determine the size of the overcurrent device. The next higher standard rating for an overcurrent device, according to 240.6, is 800 amperes. Section 230.79 requires that the service disconnecting means have a rating that is not less than the computed load (757 amperes). The minimum size of the conductors must be adequate to handle the load, but 240.4(B) permits the next larger standard-rated overcurrent device to be used.

Table 220.36 Optional Method — Permitted Load Calculations for Service and Feeder Conductors for New Restaurants

Total Connected Load (kVA)	All Electric Restaurant Calculated Loads (kVA)	Not All Electric Restaurant Calculated Loads (kVA)
0–200	80%	100%
201–325	10% (amount over 200) + 160.0	50% (amount over 200) + 200.
326–800	50% (amount over 325) + 172.5	45% (amount over 325) + 262.
Over 800	50% (amount over 800) + 410.0	20% (amount over 800) + 476.

Note: Add all electrical loads, including both heating and cooling loads, to compute the total connected load. Select the one demand factor that applies from the table, and multiply the total connected load by this single demand facto

IV. Method for Computing Farm Loads

220.40 Farm Loads — Buildings and Other Loads.

(A) Dwelling Unit. The feeder or service load of a farm dwelling unit shall be computed in accordance with the provisions for dwellings in Part II or III of this article. Where the dwelling has electric heat and the farm has electric grain-drying systems, Part III of this article shall not be used to compute the dwelling load where the dwelling and farm load are supplied by a common service.

(B) Other Than Dwelling Unit. Where a feeder or service supplies a farm building or other load having two or more separate branch circuits, the load for feeders, service conductors, and service equipment shall be computed in accordance with demand factors not less than indicated in Table 220.40.

Table 220.40 Method for Computing Farm Loads for Other Than Dwelling Unit

Ampere Load at 240 Volts Maximum	Demand Factor (Percent)
Loads expected to operate without diversity, but not less than 125 percent full-load current of the largest motor and not less than the first 60 amperes of load	100

Table 220.40 Method for Computing Farm Loads for Other Than Dwelling Unit

Ampere Load at 240 Volts Maximum	Demand Factor (Percent)
Next 60 amperes of all other loads	50
Remainder of other load	25

220.41 Farm Loads — Total.

Where supplied by a common service, the total load of the farm for service conductors and service equipment shall be computed in accordance with the farm dwelling unit load and demand factors specified in Table 220.41. Where there is equipment in two or more farm equipment buildings or for loads having the same function, such loads shall be computed in accordance with Table 220.40 and shall be permitted to be combined as a single load in Table 220.41 for computing the total load.

Table 220.41 Method for Computing Total Farm Load

Individual Loads Computed in Accordance with Table 220.40	Demand Factor (Percent)
Largest load	100
Second largest load	75
Third largest load	65
Remaining loads	50

Note: To this total load, add the load of the farm dwelling unit computed in accordance with Part II or III of this article. Where the dwelling has electric heat and the farm has electric grain-drying systems, Part III of this article shall not be used to compute the dwelling load.