

Dwelling Unit Calculations

Introduction to Unit 6—Dwelling Unit Calculations

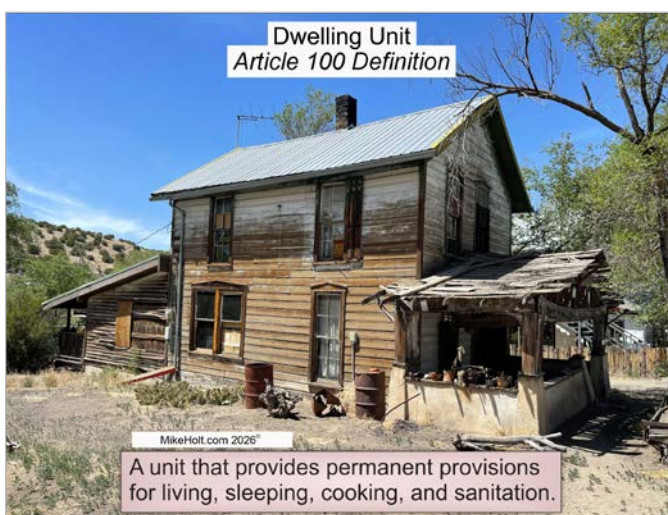
Sizing the service load for a dwelling unit is not simply a matter of adding up the individual loads or the rated current for all the breaker sizes. The *Code* recognizes there's load diversity and that not all loads will be in use simultaneously. Therefore, it provides various "demand factors" which are to be applied to calculate the "demand load."

The *Code* provides two different load calculation methods—optional and standard, and both methods are explained in this unit. Be sure to review the material as many times as needed, paying attention to the examples given, and completing the questions at the end of this unit to further solidify your understanding of these *NEC* requirements.

The following are the Parts covered in this unit:

- ▶ **Part A—Optional Method Load Calculations**
- ▶ **Part B—Standard Method Load Calculations**
- ▶ **Part C—Neutral Load Calculations**

Unit 6 focuses on sizing the service load for a dwelling unit. The *NEC* defines a dwelling unit as a space that provides living facilities with permanent provisions for living, sleeping, cooking, and sanitation. ▶[Figure 6-1](#)



▶[Figure 6-1](#)

Part A—Dwelling Unit Optional Method Load Calculations [Article 120, Part IV]

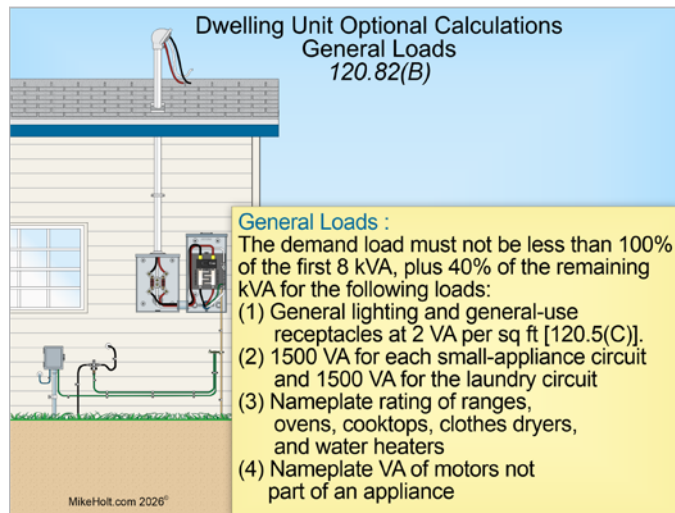
Introduction

Part A covers calculating the service demand load using the optional method contained in Article 120, Part IV. The optional method can only be used for dwelling units served by a single 120/240V or 208Y/120V, 3-wire set of service or feeder conductors with an ampacity of 100A or larger [120.82(A)]. The total service demand load is determined by a combination of 120.82(B), (C), and (D).

6.1 Dwelling Unit Optional Load Calculations [120.82]

The following steps can be used to determine the demand load on the service conductors for a dwelling unit using the optional method contained in Article 120, Part IV.

Step 1: Determine the total connected load for the general lighting and general-use receptacles, small-appliance circuits, laundry circuit, fixed appliances, and motors as follows [120.82(B)]: ▶Figure 6-2



▶Figure 6-2

(1) General Lighting. The total connected load must include a 2 VA per sq ft load for general lighting and general-use receptacles. The total square feet are based on the outside dimensions of the dwelling unit, but does not include, detached garages, open porches, or unused or unfinished spaces not adaptable for future use.

(2) Small-Appliance and Laundry Circuits. Two 20A, 120V small-appliance circuits, and one 20A, 120V circuit for the laundry area [210.11(C)(1) and 210.11(C)(2)] are required for each dwelling unit. The load for each of these circuits is based on 1500 VA.

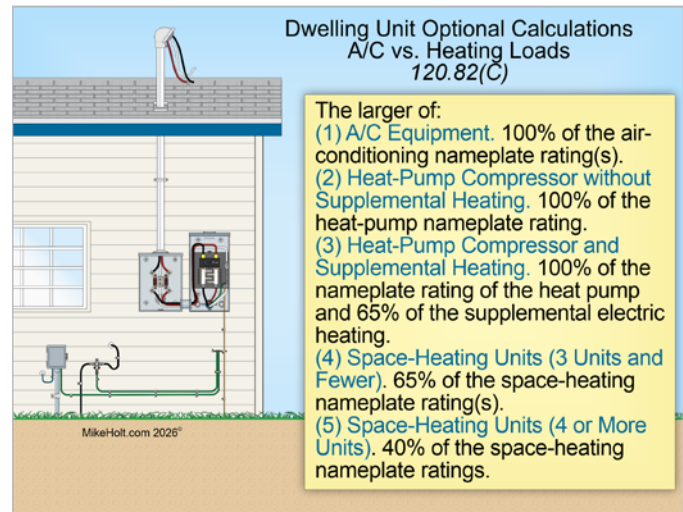
Where a dwelling unit is in a multifamily building that includes laundry facilities for the use of all building occupants, a laundry circuit is not required in each dwelling unit [210.52(F) Ex].

(3) Fixed Appliances. The nameplate VA rating of all appliances such as dishwashers, waste disposals, microwaves, trash compactors, water heaters, dryers, cooking equipment, and circuits for ironing stations, elevators, RVs, welders, and so forth must all be included.

(4) Motor VA. The VA nameplate rating of motors not part of an appliance used for irrigation, boat lifts, wells, and so on must be included at 100 percent.

Step 2: Determine the demand load for the loads contained in Step 1. This is accomplished by applying a 100 percent demand load to the first 8 kVA of the total connected load, then a 40 percent demand to the remainder of the total connected load.

Step 3: Determine the largest of the air-conditioning versus heating demand load [120.82(C)] as follows: ▶Figure 6-3



▶Figure 6-3

(1) Air-Conditioning. 100 percent of the air-conditioning nameplate rating.

(2) Heat-Pump Compressor without Supplemental Heating. 100 percent of the heat-pump nameplate rating.

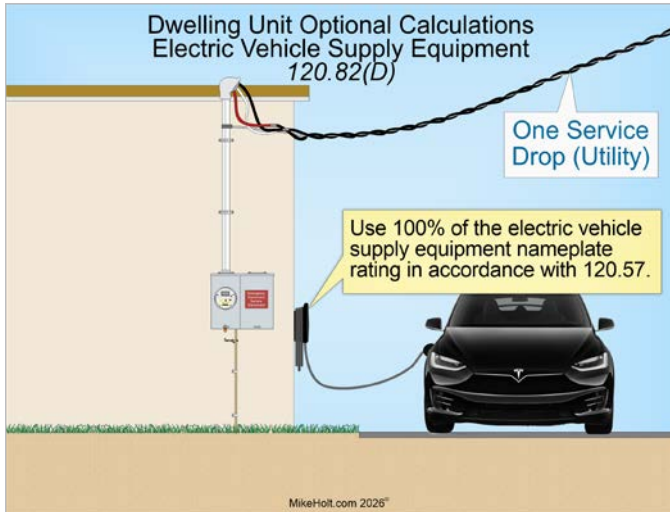
(3) Heat-Pump Compressor and Supplemental Heating. 100 percent of the nameplate rating of the heat pump and 65 percent of the supplemental electric heat rating.

(4) Space-Heating, Three Units and Less. 65 percent of the space-electric heating nameplate rating.

(5) Space-Heating, Four or More Units. 40 percent of the space-electric heating nameplate rating.

Step 4: Determine the electric vehicle supply equipment load at 100 percent [120.57 and 120.82(D)]. ▶Figure 6-4

Step 5: Determine the total demand load to size the service disconnect and service conductor in accordance with 310.12(A).



► Figure 6-4

6.2 Optional Method—Dwelling Unit Optional Load Calculation [120.82]

► Optional Method—Dwelling Unit Load Calculation [120.82] Example

Question: What is the service load for a 6,000 sq ft dwelling unit containing the following loads? ► Figure 6-5

Dwelling Unit Optional Load Calculation
120.82 Example

6,000 sq ft dwelling unit contains:

• Dishwasher, 12A at 120V	• Vent Fan, ½ hp at 120V
• Disposal (Waste), 10A at 120V	• Dryer, 4,000W at 120/240V
• Trash Compactor, 8A at 120V	• Range, 14,000W at 120/240V
• Water Heater, 4,500W at 240V	• A/C Condenser, 30A at 240V
• Microwave, 16A at 120V	• Electric Heating, 9.6 kW
	• Electric Vehicle, 40A at 240V

► Figure 6-5

- Dishwasher, 12A at 120V
- Disposal (Waste), 10A at 120V
- Trash Compactor, 8A at 120V
- Water Heater, 4,500W at 240V
- Microwave, 16A at 120V

- Vent Fan, ½ hp at 120V
- Dryer, 4,000W at 120/240V
- Range, 14,000W at 120/240V
- A/C Condenser, 30A at 240V
- Electric Heating, 9.6 kW
- Electric Vehicle, 40A at 240V

- (a) 166A (b) 171A (c) 176A (d) 181A

Solution:

Step 1: Determine the total connected load, less air-conditioning and electric heating [120.82(B)].

General Lighting	6,000 sq ft × 2 VA	12,000 VA
Small-Appliance Circuits	1,500 VA × 2 circuits	3,000 VA
Laundry Circuit		1,500 VA

Fixed Appliances and Equipment:

Dishwasher	120V × 12A	1,440 VA
Disposal (Waste)	120 × 10A	1,200 VA
Trash Compactor	120V × 8A	960 VA
Water Heater	4,500W	4,500 W
Microwave	120V × 16A	1,920 VA
Vent Fan, ½ hp	120V × 9.8A	1,176 VA
Dryer	4,000W	4,000 W
Cooking, Range	14,000W	+14,000 W
Total Connected Load		45,696 VA

Step 2: Determine the demand load for Step 1 loads [120.82(B)].

Total Connected Load	45,696 VA	
First 8 kW at 100%	-8,000 VA × 100%	8,000 VA
Remainder at 40%	37,696 VA × 40%	+15,078 VA
Demand Load		23,078 VA

Step 3: Determine the air-conditioning versus electric heating demand load [120.82(C)], air-conditioning at 100 percent [120.82(C)(1)] versus electric heating at 65 percent [120.82(C)(4)].

Air-Conditioning = Volts × Amperes

Air-Conditioning = 240V × 30A

Air-Conditioning = 7,200 VA

Electric Heating at 65%:

Electric Heating Zone = 9,600W

Space Heating Demand Load = 9,600W × 65%

Space Heating Demand Load = 6,240W, omit as it is smaller a/c 120.82(C)

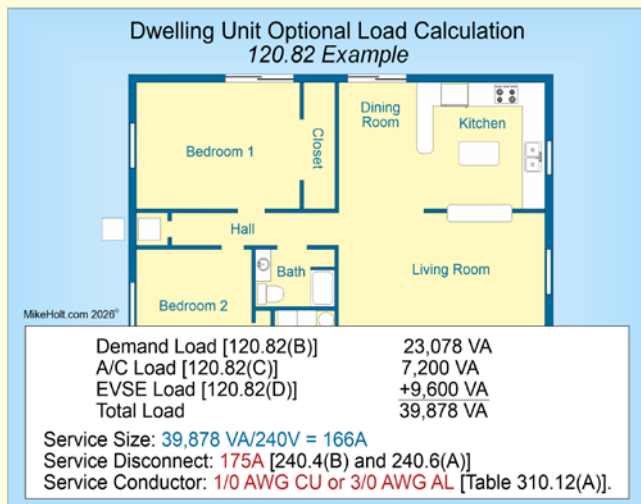
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Step 4: Determine the EVSE load at 100 percent [120.57 and 120.82(D)].

$$40A \times 240V = 9,600 \text{ VA}$$

Step 5: Determine the service load in amperes. ▶Figure 6-6

Step 2. Demand Load	23,078 VA
Step 3. Air-Conditioning Load	7,200 VA
Step 4. EVSE Load	+9,600 VA
Total Demand Load	39,878 VA



▶Figure 6-6

Service Size in Amperes = VA Demand Load/System Volts

$$\text{Service Size in Amperes} = 39,878 \text{ VA}/240V$$

$$\text{Service Size in Amperes} = 166A$$

Service disconnect size is 175A [240.4(B) and 240.6(A)].

Service conductor size is 1/0 AWG copper or 3/0 AWG aluminum [Table 310.12(A)].

Answer: (a) 166A

Part B—Dwelling Unit Standard Method Load Calculations [Article 120, Part III]

Introduction

Part B covers calculating the service demand load using the standard method contained in Article 120, Part III. It is important to be familiar with the requirements of Article 120 so the proper demand

factors are correctly applied. To keep your calculations organized and more importantly accurate, the standard calculation method should be worked in the following order:

- ▶ Step 1: General Lighting Load
- ▶ Step 2: Appliances
- ▶ Step 3: Clothes Dryers
- ▶ Step 4: Cooking Equipment
- ▶ Step 5: Electric Vehicle Supply Equipment
- ▶ Step 6: Air-Conditioning versus Heating
- ▶ Step 7: Service Size

6.3 Dwelling Unit Standard Method Load Calculations

The following steps can be used to determine the demand load on the service conductors for a dwelling unit using the standard method contained in Article 120, Part III.

Step 1: Determine the load for general lighting and general-use receptacles, plus the small-appliance and laundry circuits [120.41 and Table 120.45]. The first step is to determine the total connected load for the general lighting and general-use receptacles, small-appliance circuits, laundry circuit, and fixed appliances as follows:

(1) General Lighting. The total connected load must include a 2 VA per sq ft load for general lighting and general-use receptacles. The total square feet are based on the outside dimensions of the dwelling unit, but does not include detached garages, open porches or unused or unfinished spaces not adaptable for future use.

(2) Small-Appliance and Laundry Circuits. Two 20A, 120V small-appliance circuits and one 20A, 120V circuit for the laundry area [210.11(C)(1) and 210.11(C)(2)] are required for each dwelling unit. The load for each of these circuits is based on 1500 VA.

Step 2: Determine the appliance demand load [120.53]. Appliances include disposals (waste), dishwashers, trash compactors, water heaters, and so forth. The demand load is determined by applying a 75 percent demand factor to the nameplate rating when there are four or more appliances. There's no demand factor applied to appliances when there are three or less.

Step 3: Determine the clothes dryer demand load [120.54]. When a dryer is to be installed, the greater of the dryer nameplate rating or 5000W must be used.

Step 4: Determine the electric cooking equipment demand load [120.55]. The demand load for electric cooking equipment is determined in accordance with 120.55.

Step 5: Determine the electric vehicle supply equipment load (EVSE) [120.57]. The EVSE load is determined at the larger of 7200 VA or the nameplate rating of the equipment.

Step 6: Determine the air-conditioning versus heating demand load [120.6]. Select the larger of the air-conditioning load [120.50] and compare it to the electric heating load [120.51] if they're not both likely to be on at the same time.

Step 7: Determine the service disconnect and conductor sizing [310.12(A)]. First, add up the demand loads for the general lighting, small-appliance circuits, fixed appliances, dryers, cooking equipment, other loads, air-conditioning, heat, motor, and EVSE loads. Divide the total by the nominal system voltage. Next, size the service disconnect in accordance with the standard size over-current protective device contained in 240.6(A). Dwelling unit service conductors supplied by 120/240V systems can be sized in accordance with 310.12(A) for service conductors.

6.4 General Lighting and General-Use Receptacle Demand Load [120.41 and Table 120.45]

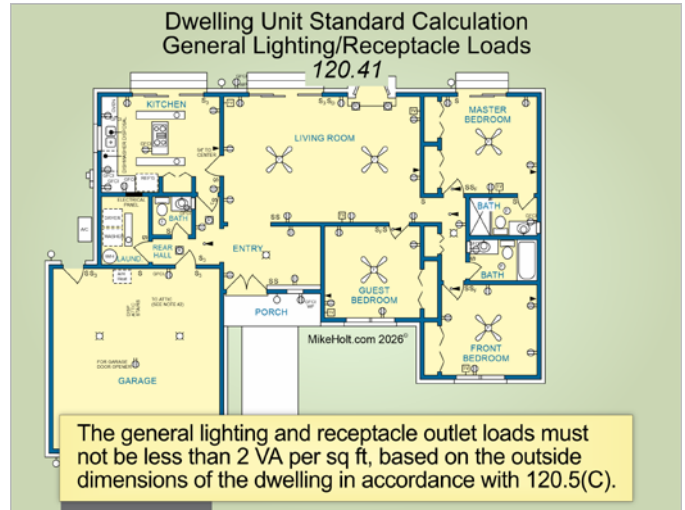
Due to "load diversity," the Code permits the application of Table 120.45 demand factors to the total connected load. To determine the feeder demand load for these circuits, use the following steps:

Step 1: Determine the total connected load for the following [120.41]:

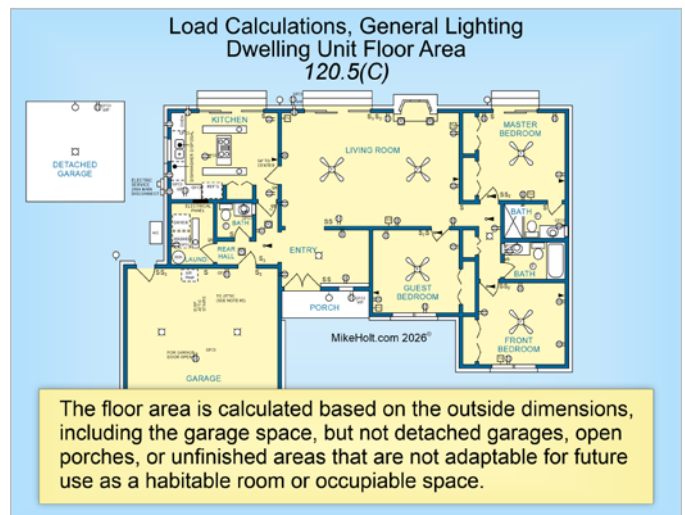
(1) General Lighting. General lighting and general-use receptacles at 2 VA per sq ft. The dimensions for determining the area are based on the outside dimensions of the building and do not include, detached garages, open porches or spaces not adaptable for future use [120.5(C)]. ▶Figure 6-7 and ▶Figure 6-8

(2) Appliances. Two small-appliance circuits each at 1500 VA [210.11(C)(1), 210.52(B), and 120.52(A)]. ▶Figure 6-9

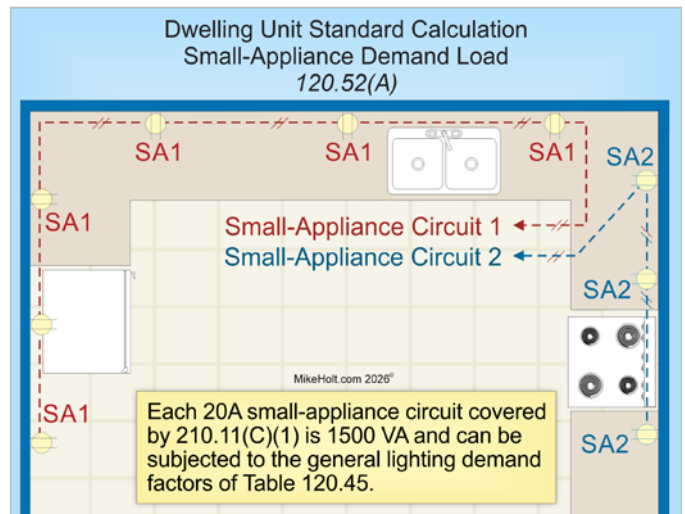
(3) Laundry Circuits. One laundry circuit at 1500 VA [210.11(C)(2) and 210.52(F), and 120.52(B)]. ▶Figure 6-10



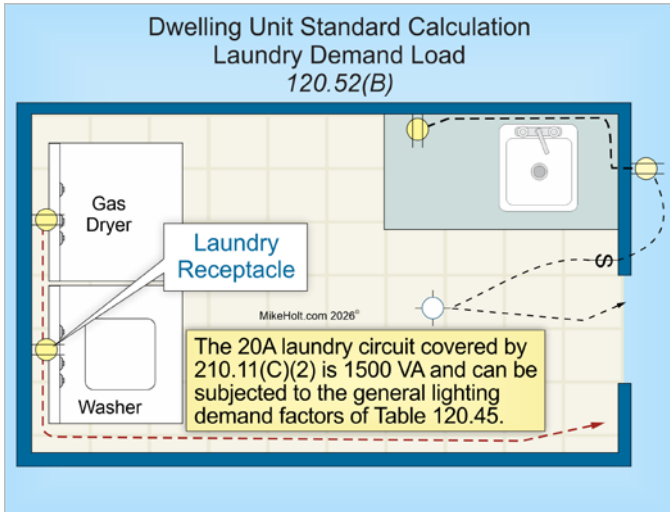
▶Figure 6-7



▶Figure 6-8



▶Figure 6-9



►Figure 6-10

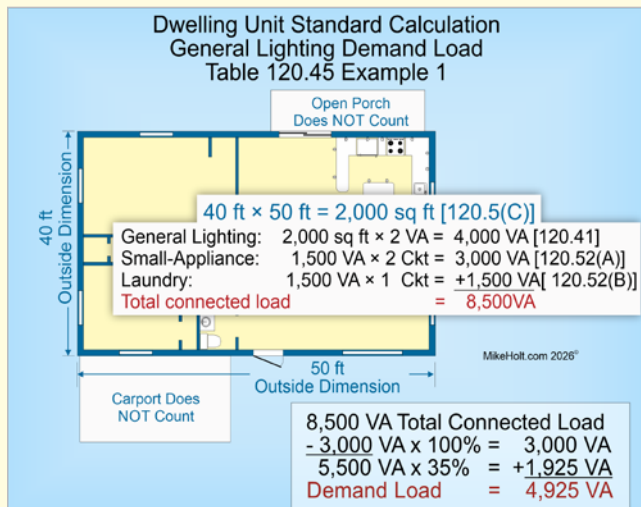
Step 2: Determine the general lighting and general-use demand load. Apply the Table 120.45 demand factors to the total connected load (from Step 1) by the following factors:

- (1) First 3000 VA of Step 1 at a 100 percent demand factor
- (2) The remaining VA of Step 1 at a 35 percent demand factor

► **Standard Method—General Lighting Demand Load Example 1**

Question: What is the general lighting and general-use receptacle, small-appliance, and laundry circuit demand load for a 40 ft × 50 ft dwelling unit? ►Figure 6-11

- (a) 3,925 VA (b) 4,925 VA (c) 5,925 VA (d) 6,925 VA



►Figure 6-11

Solution:

Step 1: Determine the general lighting, general-use receptacles, small-appliance, and laundry circuit connected load [120.41].

General Lighting [120.41]	2,000 sq ft × 2 VA	4,000 VA
Small-Appliances [120.52(A)]	1,500 VA × 2 circuits	3,000 VA
Laundry Circuit [120.52(B)]	1,500 VA × 1 circuit	+1,500 VA
Total General Lighting		8,500 VA

Step 2: Determine demand load [Table 120.45].

Total General Lighting	8,500 VA	
First 3,000 VA at 100%	-3,000 VA × 100%	3,000 VA
Next 117,000* VA at 35%	-5,500 VA × 35%	+1,925 VA
General Lighting and General-Use		4,925 VA

***Note:** Remember to subtract 3,000 VA from 120,000 VA when using Table 120.45 since the 35 percent only applies to 117,000 VA of the 3,001 VA to 120,000 VA range.

Answer: (b) 4,925 VA

► **Standard Method—General Lighting Demand Load Example 2**

Question: What is the general lighting and general-use receptacle, small-appliance, and laundry circuit demand load for a 4,000 sq ft dwelling unit? ►Figure 6-12

- (a) 4,325 VA (b) 5,325 VA (c) 6,325 VA (d) 7,325 VA

Solution:

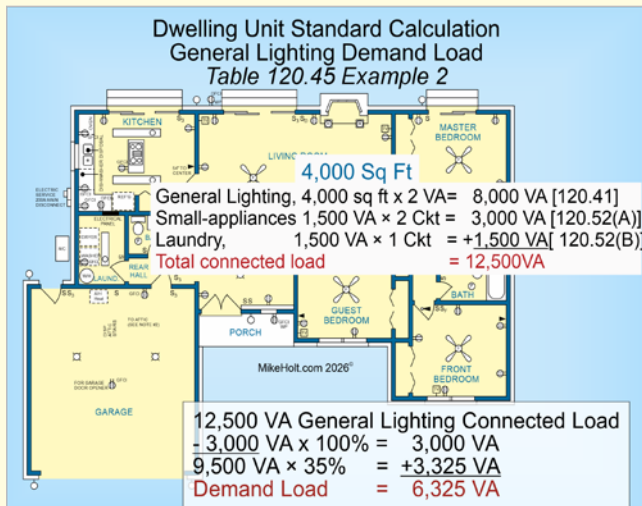
Step 1: Determine the general lighting, general-use receptacles, small-appliance, and laundry circuit connected load [120.41].

General Lighting [120.41]	4,000 sq ft × 2 VA	8,000 VA
Small-Appliances [120.52(A)]	1,500 VA × 2	3,000 VA
Laundry Circuit [120.52(B)]	1,500 VA × 1	+ 1,500 VA
Total Connected Load		12,500 VA

Step 2: Determine demand load [Table 120.45].

Total Connected Load	12,500 VA	
First 3,000 VA at 100%	-3,000 VA × 100%	3,000 VA
Remainder at 35%	9,500 VA × 35%	+ 3,325 VA
Demand Load		6,325 VA

Answer: (c) 6,325 VA

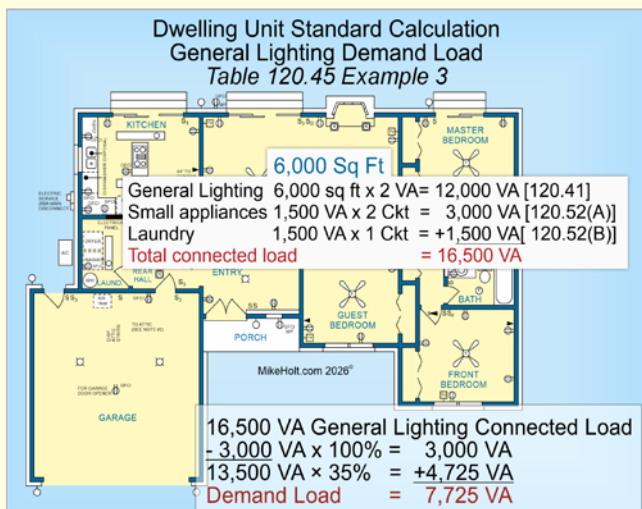


▶Figure 6-12

▶ Standard Method—General Lighting Load Example 3

Question: What is the general lighting and general-use receptacle, small-appliance, and laundry circuit demand load for a 6,000 sq ft dwelling unit? ▶Figure 6-13

(a) 4,725 VA (b) 5,725 VA (c) 6,725 VA (d) 7,725 VA



▶Figure 6-13

Solution:

Step 1: Determine the general lighting, general-use receptacles, small-appliance, and laundry circuit connected load [120.41].

General Lighting [120.41]	6,000 sq ft x 2 VA	12,000 VA
Small-Appliances [120.52(A)]	1,500 VA x 2	3,000 VA
Laundry Circuit [120.52(B)]	1,500 VA x 1	+ 1,500 VA
Total Connected Load		16,500 VA

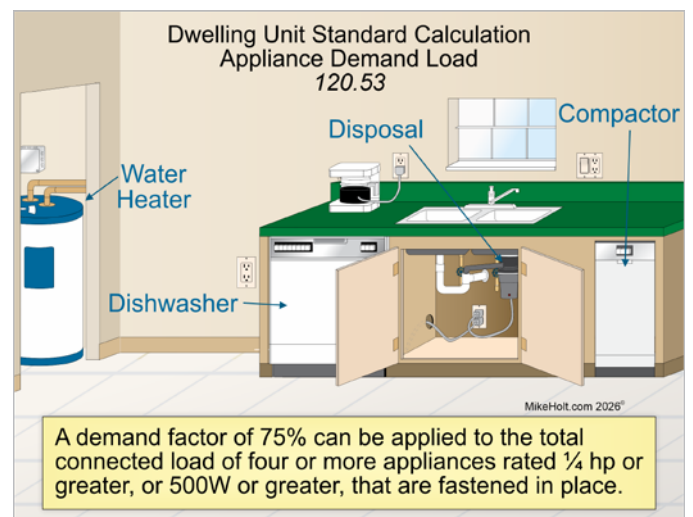
Step 2: Determine demand load [Table 120.45].

Total Connected Load	16,500 VA	
First 3,000 VA at 100%	-3,000 VA x 100%	3,000 VA
Remainder at 35%	13,500 VA x 35%	+ 4,725 VA
Demand Load		7,725 VA

Answer: (d) 7,725 VA

6.5 Fixed Appliance Demand Load [120.53]

Fixed appliances include waste disposals, dishwashers, trash compactors and so forth. The demand load is determined by adding the nameplate ratings of the appliances together and applying a 75 percent demand factor when there are four or more appliances. There is no demand factor applied to fixed appliances when there are three or less, nor is there a 75% demand factor for less than ¼ hp or lower than 500w loads like a typical bathroom exhaust fan. ▶Figure 6-14



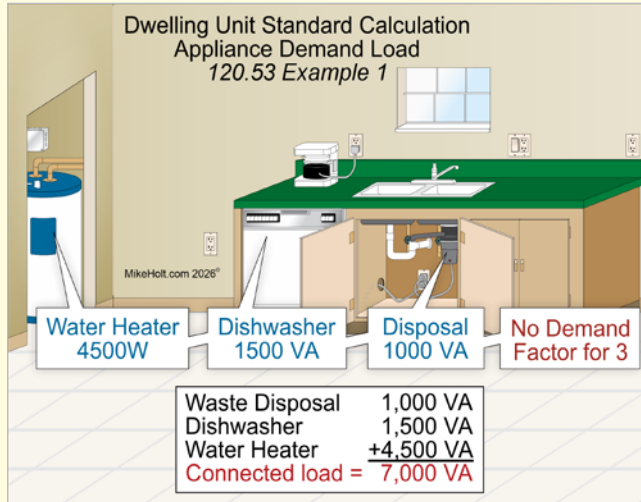
▶Figure 6-14

Heating and air-conditioning equipment, cooking appliances, clothes dryers, motors, EVSEs, and other loads are not considered fixed appliances for the purposes of the 75 percent demand factor contained in 120.53.

► **Standard Method—Fixed Appliance Demand Load Example 1**

Question: What's the service demand load for a dishwasher (1,500 VA), waste disposal (1,000 VA), and a water heater (4,500W)? ▶**Figure 6-15**

- (a) 5,000 VA (b) 6,000 VA (c) 7,000 VA (d) 8,000 VA



▶**Figure 6-15**

Solution:

Dishwasher	1,500 VA
Waste disposal	1,000 VA
Water Heater	+4,500 W
Demand Load	7,000 VA

The demand factor of 75 percent does not apply since there are only three fixed appliances.

Answer: (c) 7,000 VA

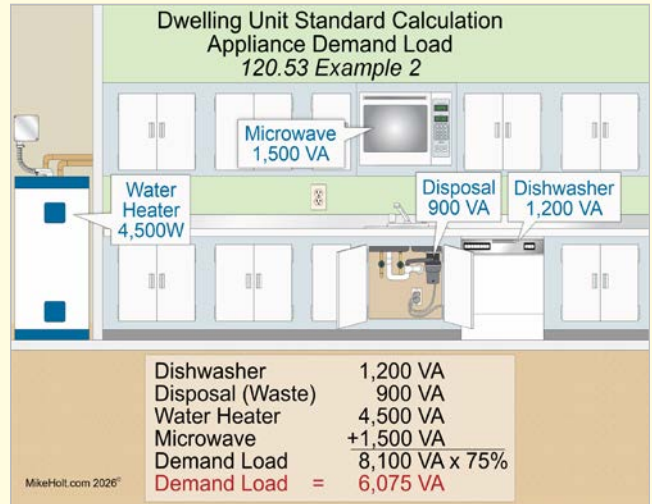
► **Standard Method—Fixed Appliance Demand Load Example 2**

Question: What's the service demand load for a dishwasher (1,200 VA), waste disposal (900 VA), a water heater (4,500W) and a microwave (1,500 VA)? ▶**Figure 6-16**

- (a) 4,075 VA (b) 5,075 VA (c) 6,075 VA (d) 7,075 VA

Solution:

Dishwasher	1,200 VA
Waste disposal	900 VA
Water Heater	4,500 VA
Microwave	+1,500 VA
Demand Load	8,100 VA



▶**Figure 6-16**

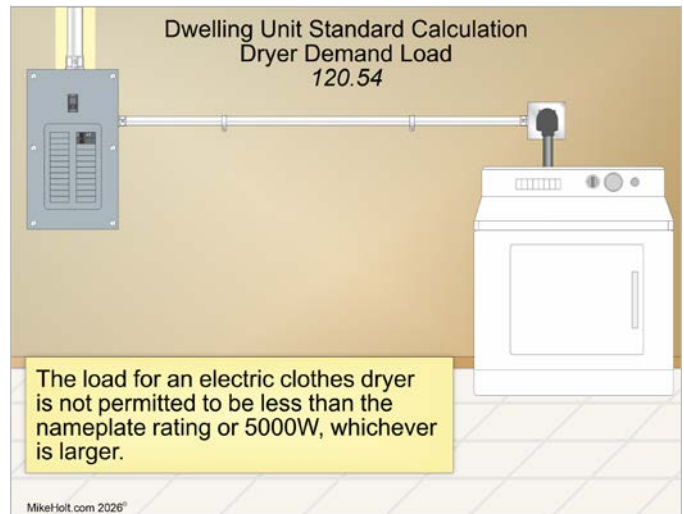
$Demand\ Load = 8,100\ VA \times 75\%$

$Demand\ Load = 6,075\ VA$

Answer: (c) 6,075 VA

6.6 Dryer Demand Load [120.54]

When a dryer is to be installed, the larger of the nameplate rating or 5000W must be used. ▶**Figure 6-17**



▶**Figure 6-17**

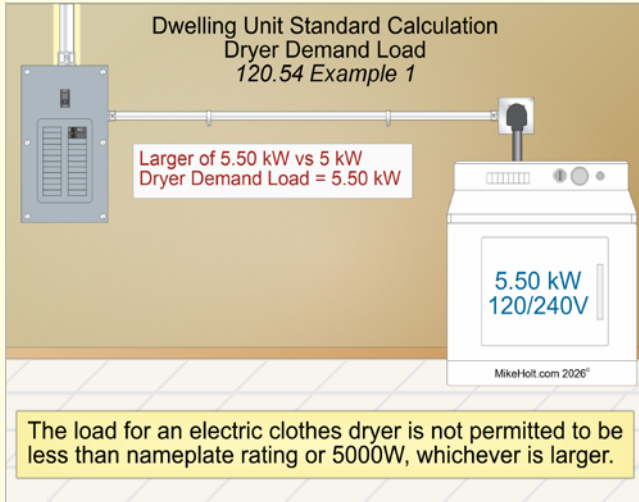
Author's Comment:

- ▶ A dryer outlet is not required to be installed in a dwelling unit. However, if it is installed, the load is not permitted to be less than 5000W or the nameplate (if larger).

► **Standard Method—Dryer Demand Load Example 1**

Question: What is the service demand load for a 5.5 kW clothes dryer? ► **Figure 6-18**

- (a) 5.5 kW (b) 5.6 kW (c) 5.7 kW (d) 5.8 kW



► **Figure 6-18**

Solution:

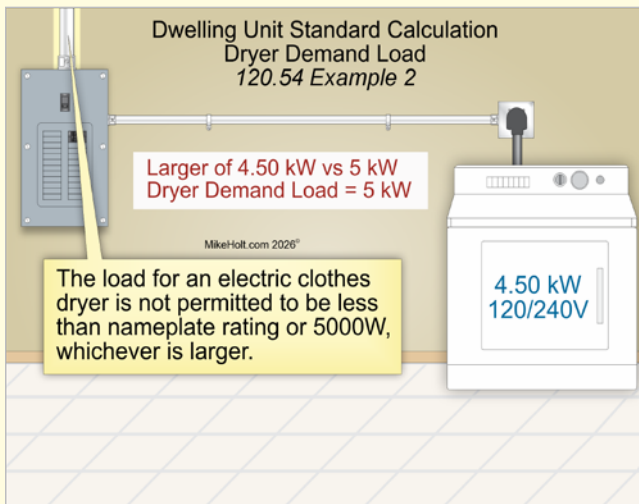
Use 5.5 kW as it is larger than 5,000W.

Answer: (a) 5.5 kW

► **Standard Method—Dryer Demand Load Example 2**

Question: What is the service demand load for a 4.5 kW clothes dryer? ► **Figure 6-19**

- (a) 4.5 kW (b) 5 kW (c) 5.5 kW (d) none of these



► **Figure 6-19**

Solution:

Use 5 kW as it is larger than 4.5 kW.

Answer: (b) 5 kW

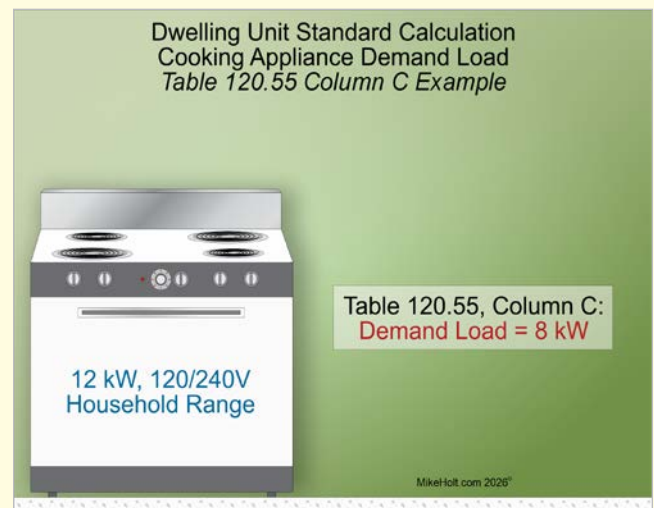
**6.7 Electric Cooking Equipment
Demand Load [120.55]**

The demand load for electric cooking equipment is determined in accordance with 120.55 and Table 120.55, including Table Notes.

► **Standard Method—Table 120.55 Column C, Over 8¾ kW to 12 kW Example**

Question: What is the service demand load for one 12 kW range? ► **Figure 6-20**

- (a) 6 kW (b) 8 kW (c) 10 kW (d) 12 kW



► **Figure 6-20**

Solution:

Table 120.55 Column C Calculated Load = 8 kW

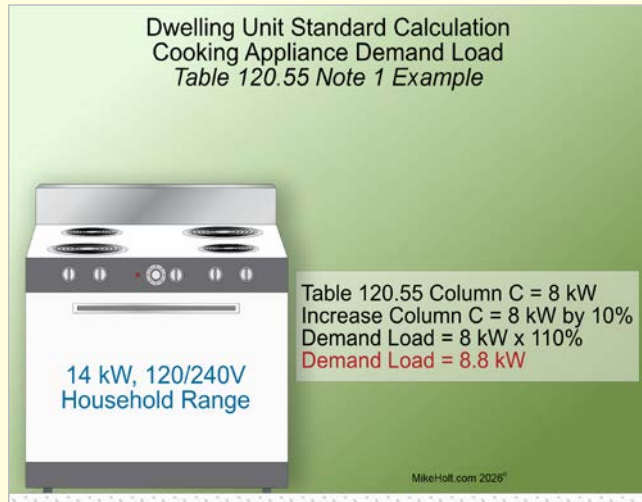
Answer: (b) 8 kW

Table 120.55 Note 1: For ranges rated more than 12 kW, the maximum demand in Column C must be increased 5 percent for each additional kilowatt of rating (or major fraction thereof), by which the rating of the range exceeds 12 kW.

► Standard Method—Table 120.55 Column C Note 1, Over 12 kW Example

Question: What is the service demand load for one 14 kW range? ►Figure 6-21

- (a) 6.6 kW (b) 8.8 kW (c) 11 kW (d) 12 kW



►Figure 6-21

Solution:

Step 1: Determine the Table 120.55, Column C demand load for one 14 kW range.

Step 2: Because the range is 14 kW, it exceeds 12 kW by 2 kW. Column C demand load must be increased by 5 percent for each kW or major fraction of a kW that exceeds 12 kW.

Step 3: Increase the Column C load by 10 percent.

$$8 \text{ kW} \times 110\% = 8.8 \text{ kW}$$

Answer: (b) 8.8 kW [Table 120.55 Note 1]

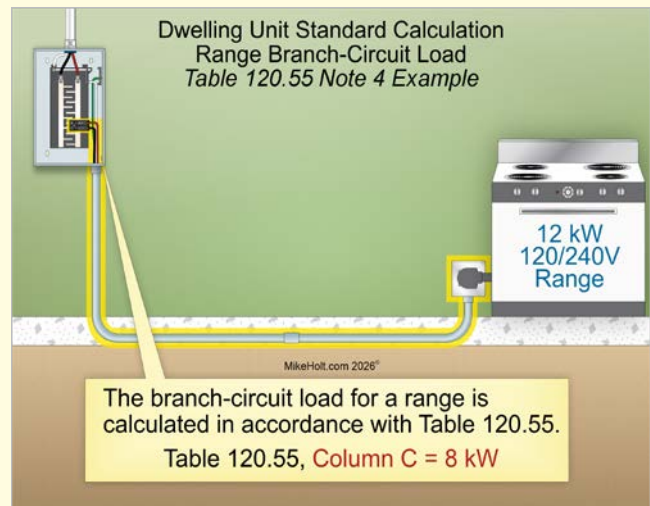
Note: For ranges rated more than 12 kW, the maximum demand in Column C must be increased 5 percent for each additional kilowatt of rating (or major fraction thereof) by which the rating of individual ranges exceeds 12 kW.

Table 120.55 Note 4: Calculating the branch-circuit load for one range in accordance with Table 120.55 is permitted.

► Standard Method—Table 120.55, Note 4 Example

Question: What is the load for branch circuit conductor sizing for a 12 kW range? ►Figure 6-22

- (a) 6 kW (b) 8 kW (c) 10 kW (d) 12 kW



►Figure 6-22

Solution:

Table 120.55 Column C Calculated Load = 8 kW

Answer: (b) 8 kW

Table 120.55 Note 5: The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit must not be less than the nameplate rating (100 percent) of the appliance.

► Standard Method—Table 120.55, Note 5 Example

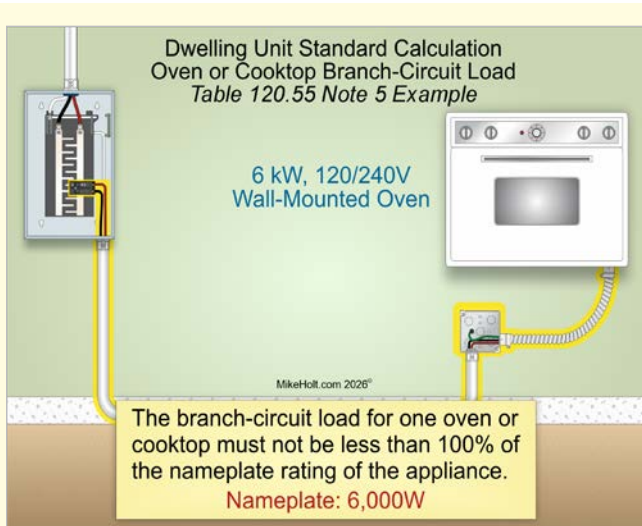
Question: What is the branch circuit load for a 6 kW wall-mounted oven? ►Figure 6-23

- (a) 4 kW (b) 4.5 kW (c) 5 kW (d) 6 kW

Solution:

Use wall-mounted oven nameplate rating at 100% [Table 120.55 Note 5].

Answer: (d) 6 kW



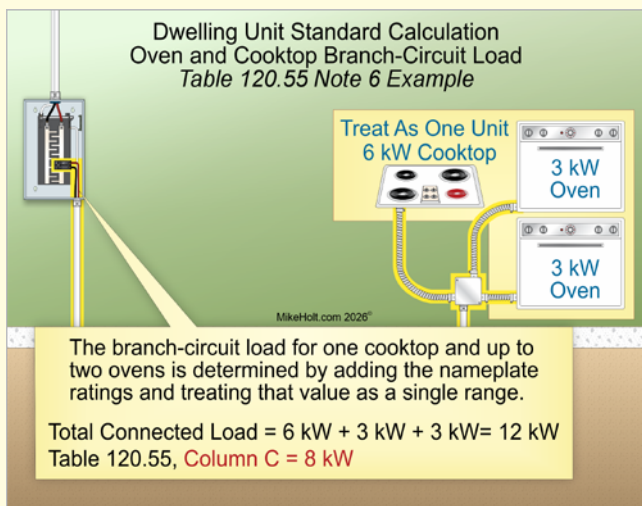
►Figure 6-23

Table 120.55 Note 6: The branch-circuit load for one counter-mounted cooking unit and up to two wall-mounted ovens is determined by adding the nameplate ratings together and treating that value as a single range to determine the load in accordance with Table 120.55 and Notes.

► **Standard Method—Table 120.55, Note 6 Example**

Question: What is the branch circuit load for a 6 kW counter-mounted cooking unit and two 3 kW wall-mounted ovens connected on a circuit? ►Figure 6-24

- (a) 6 kW (b) 8 kW (c) 10 kW (d) 12 kW



►Figure 6-24

Solution:

Step 1: Determine the total connected load.

$$\begin{aligned} \text{Total Connected Load} &= 6 \text{ kW} + 3 \text{ kW} + 3 \text{ kW} \\ \text{Total Connected Load} &= 12 \text{ kW} \end{aligned}$$

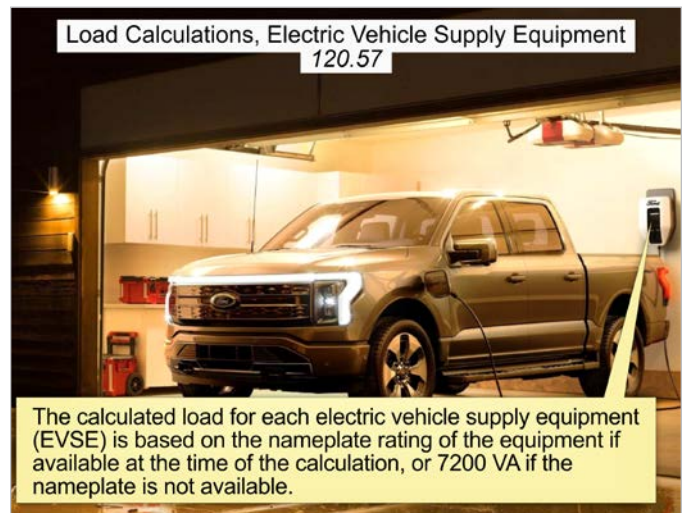
Step 2: Determine the calculated kW load as a single 12 kW range.

$$\text{Table 120.55, Column C} = 8 \text{ kW}$$

Answer: (b) 8 kW

6.8 Electric Vehicle [120.57]

The calculated load for each Electric Vehicle Supply Equipment (EVSE) is based on the nameplate rating of the equipment if available at the time of the calculation, or 7200 VA if the nameplate is not available. ►Figure 6-25

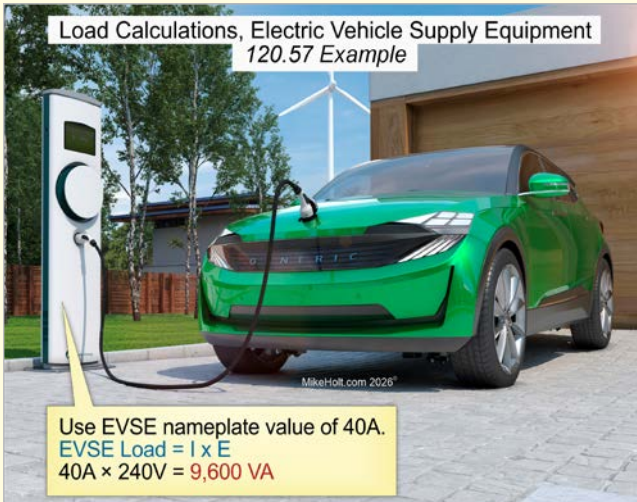


►Figure 6-25

► Electric Vehicle Supply Equipment Load Example

Question: What is the service load for an EV charger (electric vehicle supply equipment) with a nameplate rating of 40A at 240V? ▶ **Figure 6-26**

- (a) 6,200 VA (b) 7,200 VA (c) 8,600 VA (d) 9,600 VA



▶ **Figure 6-26**

Solution:

Use EVSE nameplate value of 40A.

$$\text{EVSE Load} = I \times E$$

$$\text{EVSE Load} = 40\text{A} \times 240\text{V}$$

$$\text{EVSE Load} = 9,600\text{ VA}$$

Answer: (d) 9,600 VA

6.9 Air-Conditioning Versus Heating [120.6]

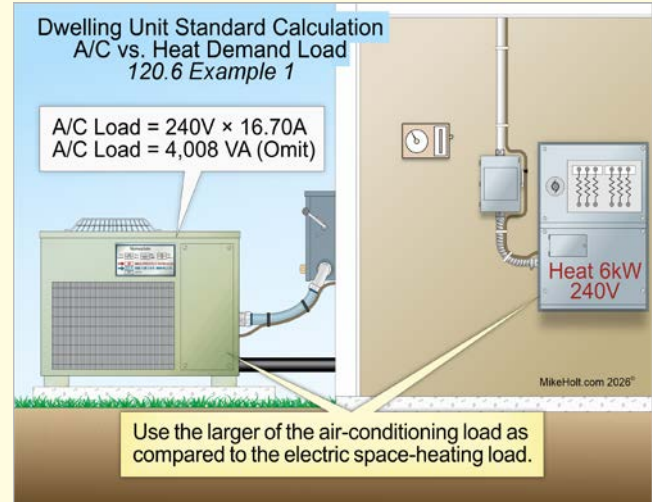
Noncoincident Loads [120.6]

Select the larger of the air-conditioning load [120.50] and compare it to the electric heating load [120.51]. Use the larger of the two if they are not both likely to be on at the same time [120.6].

► Standard Method—Air-Conditioning versus Heating Example 1

Question: What is the demand load for a 16.70A, 240V air-conditioning unit and a 6 kW, 240V electric space heater? ▶ **Figure 6-27**

- (a) 5 kW (b) 6 kW (c) 7 kW (d) 8 kW



▶ **Figure 6-27**

Solution:

Step 1: Determine the air-conditioning load at 100 percent in accordance with 120.50(B).

$$\text{Air-Conditioning VA Load} = 240\text{V} \times 16.70\text{A}$$

$$\text{Air-Conditioning VA Load} = 4,008\text{ VA}$$

Step 2: Determine the electric space-heating load at 100 percent in accordance with 120.51.

$$\text{Electric Space-Heating Load} = 6,000\text{W}$$

Step 3: Determine the larger of air-conditioning load at 100 percent as compared to the electric space-heating load at 100 percent in accordance with 120.6.

$$\text{Electric Space-Heating Load} = 6,000\text{W}$$

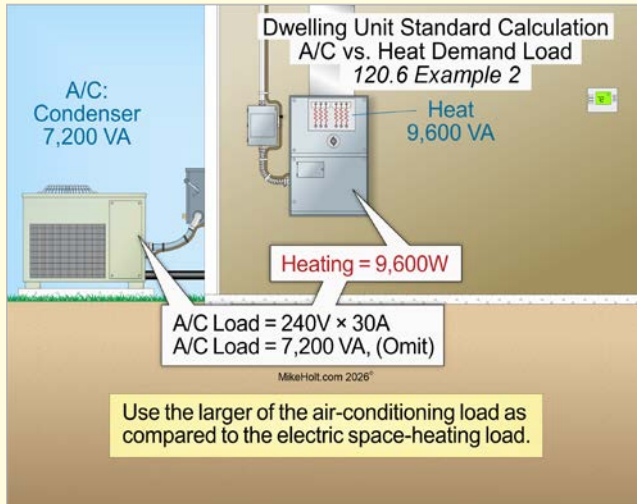
Answer: (b) 6 kW

► Standard Method—Air-Conditioning versus Heating Example 2

Question: What is the service demand load for a dwelling unit with an air conditioner rated 30A at 240V versus electric heating of 9.6 kW?

►Figure 6–28

(a) 7.6 kVA (b) 9.6 kW (c) 11.6 kVA (d) 13.6 kVA



►Figure 6–28

Solution:

Step 1: Determine the air-conditioning load at 100 percent in accordance with 120.50(B).

Air-Conditioning = Volts × Amperes

$$\text{A/C Condenser} = 240\text{V} \times 30\text{A}$$

A/C Condenser = 7,200 VA, omit as it is smaller than heat [120.6]

Step 2: Determine the electric space-heating load at 100 percent in accordance with 120.51.

$$\text{Electric Space-Heating Load} = 9,600\text{W}$$

Step 3: Determine the larger of air-conditioning load at 100 percent as compared to the electric space-heating load at 100 percent in accordance with 120.6.

$$\text{Electric Space-Heating Load} = 9,600\text{W}$$

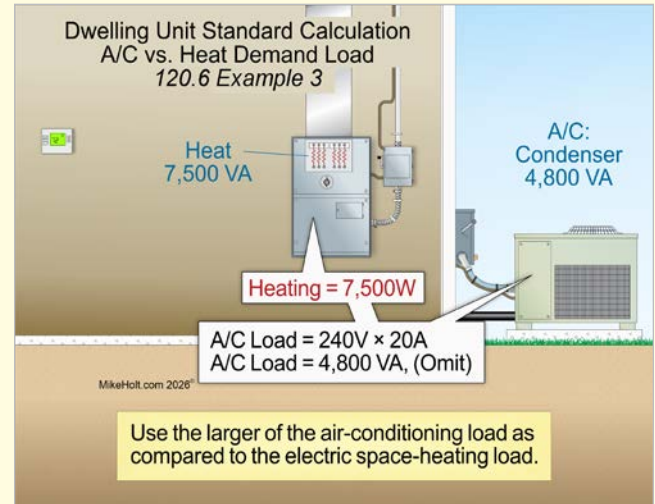
Answer: (b) 9.6 kW

► Standard Method—Air-Conditioning versus Heating Example 3

Question: What is the service demand load for a dwelling unit with an air conditioner rated 20A at 240V versus electric heating of 7.5 kW?

►Figure 6–29

(a) 7 kVA (b) 7.5 kW (c) 8 kVA (d) 9 kVA



►Figure 6–29

Solution:

Step 1: Determine the air-conditioning load at 100 percent in accordance with 120.50(B).

Air-Conditioning = Volts × Amperes

$$\text{A/C Condenser} = 240\text{V} \times 20\text{A}$$

A/C Condenser = 4,800 VA, omit as it is smaller than heat [120.6]

Step 2: Determine the electric space-heating load at 100 percent in accordance with 120.51.

$$\text{Electric Space-Heating Load} = 7,500\text{W}$$

Step 3: Determine the larger of air-conditioning load at 100 percent as compared to the electric space-heating load at 100 percent in accordance with 120.6.

$$\text{Electric Space-Heating Load} = 7,500\text{W}$$

Answer: (b) 7.5 kW

6.10 Service Conductor Size [Table 310.12(A)]

Services

Service conductors rated 75°C or greater supplying the entire load associated with a dwelling unit can be sized in accordance with Table 310.12(A) where there is no conductor ampacity adjustment or correction as required by 310.15(B) or (C).

Step 1: Add up the demand loads for general-lighting, fixed appliances, dryers, cooking equipment, air-conditioning, heat, and motors. Divide this sum by the nominal system voltage.

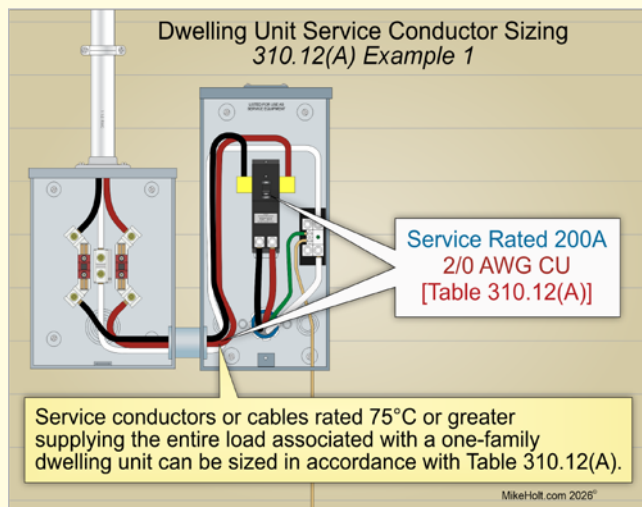
Step 2: Next, size the service disconnect. Size service disconnect in accordance with the standard size overcurrent protective device contained in 240.6(A).

Step 3: Size the service conductor ampacity for one-family dwellings and individual dwelling units of two-family and multi-family dwellings. Size service conductor in accordance with Table 310.12(A) where the calculated demand load does not exceed 400A. When the calculated demand load exceeds 400A, the service conductor must be sized in accordance with Table 310.16.

► Standard Method—Service Conductor Size Example 1

Question: What size service copper conductors are required for a dwelling unit that has a 200A service disconnect? ►Figure 6-30

- (a) 1/0 AWG (b) 2/0 AWG (c) 3/0 AWG (d) 4/0 AWG



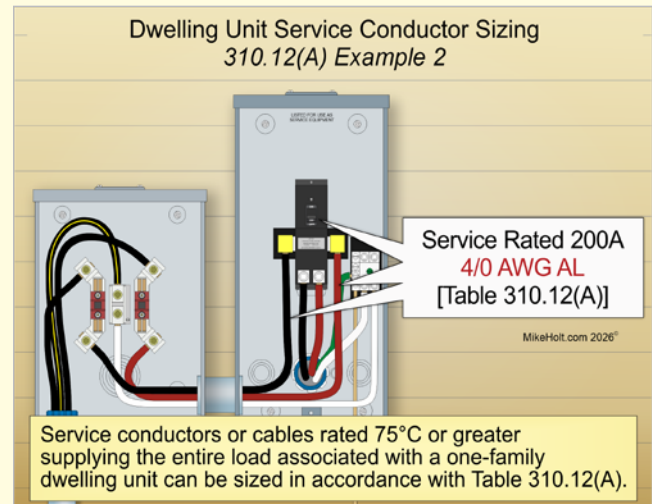
►Figure 6-30

Answer: (b) 2/0 AWG [Table 310.12(A)]

► Standard Method—Service Conductor Size Example 2

Question: What size service aluminum conductors are required for a dwelling unit that has a 200A service disconnect? ►Figure 6-31

- (a) 1/0 AWG (b) 2/0 AWG (c) 3/0 AWG (d) 4/0 AWG



►Figure 6-31

Answer: (d) 4/0 AWG [Table 310.12(A)]

6.11 Standard Method Load Calculations [Article 120, Part III]

► Standard Method—Load Calculations Example [Article 120, Part III]

Question: What is the service load for a dwelling unit of 6,000 sq ft having the following loads?

- Dishwasher, 12A at 120V
- Waste Disposal, 10A at 120V
- Trash Compactor, 8A at 120V
- Water Heater, 4,500W at 240V
- Microwave, 16A at 120V
- Vent Fan, 7.2A at 120V
- Dryer, 4,000W at 120/240V
- Cooking, Range, 14,000W at 120/240V
- A/C Condenser, 30A at 240V
- Electric Heating, 9.6 kW
- Electric Vehicle, 40A at 240V

- (a) 204A (b) 214A (c) 224A (d) 234A

Solution:

Step 1: Determine the general lighting, general-use receptacles, small-appliance circuit, and laundry circuit demand load.

General Lighting [120.41]	6,000 sq ft × 2 VA	12,000 VA
Small-Appliances [120.52(A)]	1,500 VA × 2	3,000 VA
Laundry Circuit [120.52(B)]	1,500 VA × 1	+ 1,500 VA
Total Connected Load		16,500 VA

Total Connected Load	16,500 VA	
First 3,000 VA at 100%	-3,000 VA × 100%	3,000 VA
Remainder at 35%	13,500 VA × 35%	+ 4,725 VA
Demand Load		7,725 VA

Step 2: Determine the fixed appliance demand load [120.53].

Dishwasher	12A × 120V	1,440 VA
Waste Disposal	10A × 120V	1,200 VA
Trash Compactor	8A × 120V	960 VA
Water Heater		4,500 W
Microwave	16A × 120V	1,920 VA
Vent Fan	7.2A × 120V	+ 864 VA
Total Connected Load		10,884 VA

Demand Load = Connected Load × Demand Factor [120.53]

$$\text{Demand Load} = 10,884 \text{ VA} \times 75\%$$

$$\text{Demand Load} = 8,163 \text{ VA}$$

Step 3: Determine the dryer demand Load [120.54].

The dryer nameplate is 4,000W, but the dryer load cannot be less than 5,000W.

$$\text{Dryer Demand Load} = 5,000 \text{ W}$$

Step 4: Determine the cooking equipment demand load [120.55].

$$\text{Column C Calculated} = 8 \text{ kW} \times 110\%$$

$$\text{Column C Calculated} = 8.8 \text{ kW}^*$$

* 14 kW exceeds 12 kW by 2 kW. The Column C value (8 kW) must be increased 5 percent for each kW over 12 kW [Table 220.55, Note 1].

2 × 5 percent is a 10 percent increase of the Column C value resulting in 110 percent.

Step 5: Determine the electric vehicle demand load [120.57].

$$\text{EV Demand Load} = 240 \text{ V} \times 40 \text{ A}$$

$$\text{EV Demand Load} = 9,600 \text{ VA}$$

Step 6: Determine air-conditioning versus electric heating demand load [120.50, 120.51, 120.6, and 430.22].

Select the larger of the air-conditioning load in the dwelling unit [120.50] and compare it to the electric heating load [120.51] if they are not both likely to be on at the same time [120.6].

Air-Conditioning = Volts × Amperes

$$\text{A/C Condenser} = 240 \text{ V} \times 30 \text{ A}$$

$$\text{A/C Condenser} = 7,200 \text{ VA}$$

Air-Conditioning Total = 7,200 VA, omit as it is smaller than heat [120.6]

Electric Heating at 100%:

$$\text{Electric Heating} = 9,600 \text{ W}$$

Step 7: Determine the service demand load VA.

Step 1. General Lighting, Receptacles, and Laundry	7,725 VA
Step 2. Fixed Appliances	8,163 VA
Step 3. Dryer	5,000 VA
Step 4. Cooking Equipment	8,800 VA
Step 5. Electric Vehicle	9,600 VA
Step 6. Heating	+ 9,600 VA
Total Demand Load	48,888 VA

Step 8: Determine the service demand load in amperes.

Service Load in Amperes = VA/Volts

$$\text{Service Load in Amperes} = 48,888 \text{ VA} / 240 \text{ V}$$

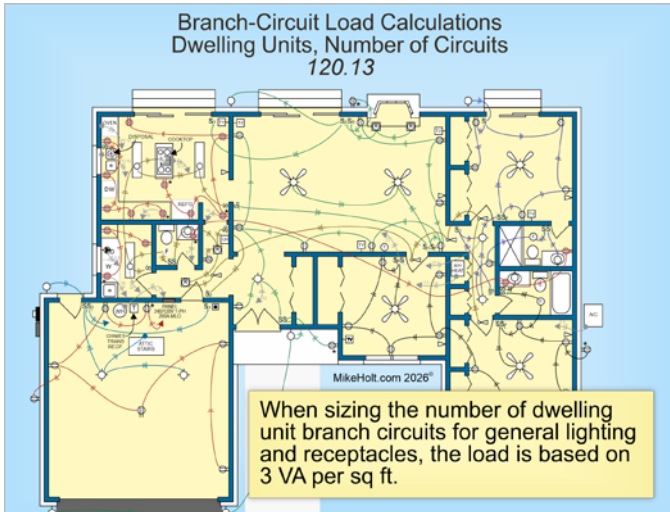
$$\text{Service Load in Amperes} = 203.7 \text{ A, round up to } 204 \text{ A}$$

Answer: (a) 204A

6.12 Number of General Lighting and General-Purpose Receptacle Circuits [210.11(A) and 120.13]

The number of branch circuits required is determined by dividing the total calculated general lighting load in amperes by the ampere rating of the circuit. See Annex D, Example D1(a) for details [210.11(A)].

When sizing the number of general-purpose branch circuits for dwelling units, the load is based on 3 VA per sq ft [120.13]. ▶**Figure 6-32**

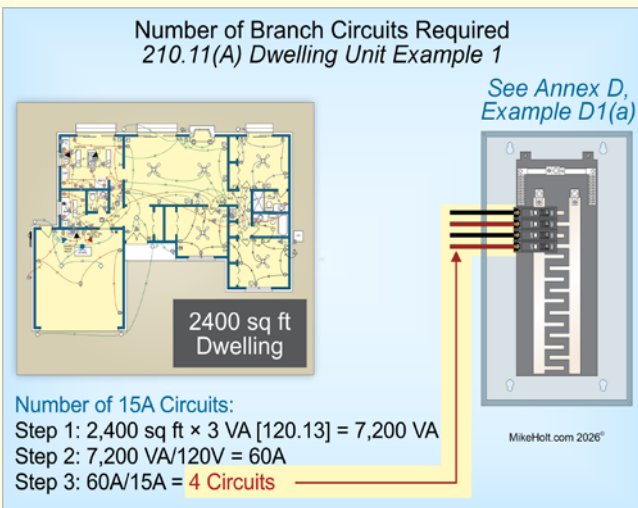


▶ Figure 6-32

▶ **Standard Method—Number of General Lighting Circuits Example 1**

Question: How many 15A, 120V circuits are required for the general lighting and general-use receptacles for a dwelling having a floor area of 2,400 sq ft? ▶ Figure 6-33

- (a) 3 circuits (b) 4 circuits (c) 5 circuits (d) 6 circuits



▶ Figure 6-33

Solution:

Step 1: Determine the total VA load.

$$VA = 2,400 \text{ sq ft} \times 3 \text{ VA per sq ft [120.13]}$$

$$VA = 7,200 \text{ VA}$$

Step 2: Determine the amperes.

$$I = \text{Volt-Ampere/Volts}$$

$$I = 7,200 \text{ VA}/120\text{V}$$

$$I = 60\text{A}$$

Step 3: Determine the number of circuits.

$$\text{Number of 15A Circuits} = 60\text{A}/15\text{A}$$

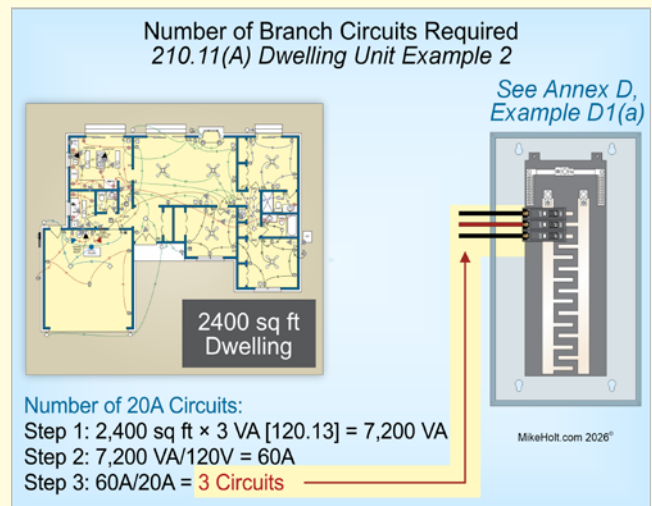
$$\text{Number of 15A Circuits} = 4$$

Answer: (b) 4 circuits

▶ **Standard Method—Number of General Lighting Circuits Example 2**

Question: How many 20A, 120V circuits are required for the general lighting and general-use receptacles for a dwelling having a floor area of 2,400 sq ft? ▶ Figure 6-34

- (a) 3 circuits (b) 4 circuits (c) 5 circuits (d) 6 circuits



▶ Figure 6-34

Solution:

Step 1: Determine the total VA load.

$$VA = 2,400 \text{ sq ft} \times 3 \text{ VA per sq ft [120.13]}$$

$$VA = 7,200 \text{ VA}$$

Step 2: Determine the amperes.

$$I = \text{Volt-Ampere/Volts}$$

$$I = 7,200 \text{ VA}/120\text{V}$$

$$I = 60\text{A}$$

Step 3: Determine the number of circuits.

$$\text{Number of 20A Circuits} = 60\text{A}/20\text{A}$$

$$\text{Number of 20A Circuits} = 3$$

Answer: (a) 3 circuits

Part C—Neutral Load Calculations

Introduction

Thus far we have covered both optional and standard methods for calculating the total service demand load in a single-family dwelling, however the neutral must be calculated using the standard method in Article 120, Part III only!

In accordance with 120.61 the neutral demand load must include 100 percent of the line to neutral loads and 70 percent of the dryer and range loads for a single-family dwelling.

6.13 Dryers and Ranges Neutral Calculations [120.61]

Dryer Neutral Load [120.61(B)(1)]

The service neutral load for electric clothes dryers can be based on 70 percent of the demand load as determined by 120.54.

► Neutral Load Calculations—Dryer Neutral Demand Example

Question: What is the neutral load for one 5.5 kW dryer? ►Figure 6–35

- (a) 3.85 kW (b) 4.85 kW (c) 5.85 kW (d) 6.85 kW

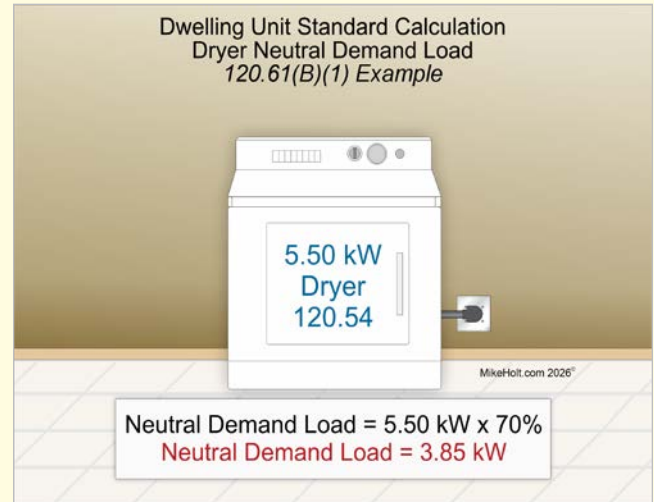
Solution:

$$\text{Neutral Calculated Demand Load} = 5.5 \text{ kW} \times 70\% [120.61(B)(1)]$$

$$\text{Neutral Calculated Demand Load} = 3.85 \text{ kW}$$

See Annex D, Examples D1(a) and D1(b) for more neutral calculations.

Answer: (a) 3.85 kW



►Figure 6–35

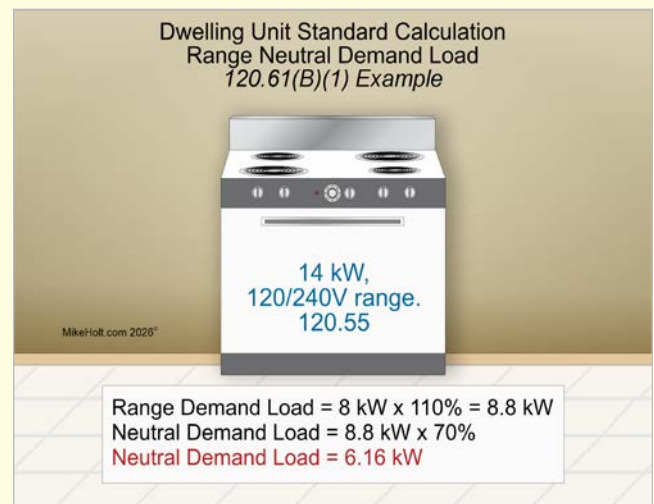
Cooking Equipment Neutral Load [120.61(B)(1)]

The neutral load for household cooking appliances, such as electric ranges, wall-mounted ovens, or counter-mounted cooking units, is calculated at 70 percent of the demand load as determined by 120.55.

► Neutral Load Calculations—Range Neutral Demand Load Example

Question: What is the neutral load for one 14 kW range? ►Figure 6–36

- (a) 3,160W (b) 4,160W (c) 5,160W (d) 6,160W



►Figure 6–36

Solution:

Step 1: Since the range exceeds 12 kW, we must comply with Note 1 of Table 120.55. The first step is to determine the demand load as listed in Column C of Table 120.55 for one unit which is 8 kW.

Step 2: The Column C value (8 kW) must be increased by 5 percent for each kVA that the range exceeds 12 kW [Table 120.55, Note 1].

$$14 \text{ kW} - 12 \text{ kW} = 2 \text{ kW}$$

2 × 5 percent is 10 percent increase of the Column C value resulting in 110 percent.

$$\text{Cooking Equipment Demand Load} = 8 \text{ kW} \times 110\%$$

$$\text{Cooking Equipment Demand Load} = 8.8 \text{ kW}$$

$$\text{Neutral Demand Load} = 8,800\text{W} \times 70\% [120.61(B)(1)]$$

$$\text{Neutral Demand Load} = 6,160\text{W}$$

Answer: (d) 6,160W

6.14 Service Neutral Calculation [120.61]

Service Neutral Calculated Load

The neutral load for feeders or services is the maximum load between the neutral conductor and any one phase conductor.

Author's Comment:

- ▶ Line-to-line loads do not place any load on the neutral conductor (example, a 240v water heater), therefore line-to-line loads are not considered in the neutral calculation (except for ranges and dryers).

▶ Neutral Load Calculations—Service Neutral Calculated Load Reductions Example

Question: What is the service neutral load for 6,000 sq ft. dwelling unit containing the following loads?

- Dishwasher, 12A at 120V
- Waste Disposal, 10A at 120V
- Microwave, 16A at 120V
- Water Heater (Tankless), 40A at 240V
- Dryer, 4,000W at 120/240V
- Cooking, Range, 14,000W at 120/240V
- Trash Compactor, 8A at 120V
- A/C Condenser, 30A at 240V
- Electric Heating, 9.6 kW at 240V

(a) 60A (b) 70A (c) 80A (d) 90A

Solution:

Step 1: Determine the general lighting and general-use receptacles, and the laundry circuit demand load [Table 120.45].

General Lighting [120.41]	6,000 sq ft × 2 VA	12,000 VA
Small-Appliances [120.52(A)]	1,500 VA × 2	3,000 VA
Laundry Circuit [120.52(B)]	1,500 VA × 1	+ 1,500 VA
Total Connected Load		16,500 VA

Total Connected Load	16,500 VA	
First 3,000 VA at 100%	-3,000 VA × 100%	3,000 VA
Remainder at 35%	13,500 VA × 35%	+ 4,725 VA
Demand Load		7,725 VA

Step 2: Determine the fixed appliance demand load [120.53].

Dishwasher	12A × 120V	1,440 VA
Disposal	10A × 120V	1,200 VA
Trash Compactor	8A × 120V	960 VA
Microwave	16A × 120V	1,920 VA
Water Heater (240V)		+ 0 VA*
Total Connected Load		5,520 VA

*Water heaters do not have neutrals.

Demand Load = Connected Load × Demand Factor [120.53]

$$\text{Demand Load} = 5,520 \text{ VA} \times 75\%$$

$$\text{Demand Load} = 4,140 \text{ VA}$$

Step 3: Determine the dryer demand load [120.54].

$$\text{Dryer (120/240V)} = 5,000W^* \times 70\% \text{ [120.61(B)]}$$

$$\text{Dryer (120/240V)} = 3,500W$$

*The dryer load cannot be less than 5,000W.

Step 4: Determine the cooking equipment demand load [Table 120.55].

$$\text{Column C Calculated} = 8 \text{ kW} \times 110\%^*$$

$$\text{Column C Calculated} = 8.8 \text{ kW}$$

*14 kW exceeds 12 kW by 2 kW. The Column C value (8 kW) must be increased 5 percent for each kW over 12 kW [Table 120.55, Note 1].

$$\text{Cooking Equipment Neutral Load} = 8,800W \times 70\% \text{ [120.61(B)(1)]}$$

$$\text{Cooking Equipment Neutral Load} = 6,160W$$

Step 5: Determine the service neutral size [310.12(D)].

Step 1. General Lighting, Receptacles, and Laundry (120V)	7,725 VA
Step 2. Fixed Appliances (120V)	4,140 VA
Step 3. Dryer (120/240V)	3,500 VA
Step 4. Cooking Equipment (120/240V)	+ 6,160 VA
Total Demand Load	21,525 VA

Step 6: Determine the service neutral size in amperes.

$$\text{Service Neutral Load in Amperes} = VA/Volts$$

$$\text{Service Neutral Load in Amperes} = 21,525 VA/240V$$

$$\text{Service Neutral Load in Amperes} = 90A$$

Answer: (d) 90A

Unit 6—Conclusion

The residential service calculations covered in this unit required you to understand and apply many different demand factors. Since not all loads are used simultaneously in a home, the service is sized on a percentage of the total connected load, based on what the *NEC* calls “demand factors.”

The *Code* doesn’t explain how demand factors were derived, and it’s not necessary for you to understand this to apply them correctly. Be sure to work on some practice calculations so you understand how to apply the various demand factors to a dwelling unit calculation. It’s important to have a good working knowledge of this before going on to Unit 7—Multifamily Dwelling Calculations which will build on the concepts developed in this unit.

Both the standard and optional service calculation methods were discussed in this unit. Remember that these are two distinctly different calculation methods, so be sure not to mix them together. On an exam, you’ll likely be told which one to use on a specific question, but if the question doesn’t specify the method, use the standard calculation.

Remember the different *Code* sections and Tables necessary to correctly answer the practice and challenge questions. Your goal should be to remember where in the *NEC* you need to look for the information you need, rather than trying to memorize the information in every *Code* section and Table.