Introduction

Stallcup's Master Electrician's Study Guide Answer Key provides you with the guidance you need to learn on your own. Available for the first time online, this helpful tool provides step-by-step solutions to every exercise problem and question outlined in *Stallcup's Master Electrician's Study Guide, 2008 Edition.* For easy navigation and quick comprehension, questions are organized exactly as they appear within the text and explanations to answers are provided where appropriate. Helping you master the 2008 *National Electrical Code*®, answers dealing with the *Code* specify the article and section the answer is based upon.

Take your time when going through both the textbook and answers. By studying the explanations and theories behind the applications, completing the review questions, and checking your work with the ***Answer Key***, you will develop a better understanding of the subject knowledge you need to succeed.

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ISBN: 9780763782115

6048

Chapter 4
Overcurrent Protection Devices and Conductors
(Exercise Problems)

Figure 4-1

[A] 23.5	[B] 29.375	[C] 29.375	[D] 60
[E] 75	[F] 29.375	[G] 30	[H] 30

Figure 4-2

[A] 90	[B] 112.5	[C] 112.5	[D] 75
[E] 112.5	[F] 2	[G] 2	[H] 115
[I] 115	[J] 125	[K] 125	

Figure 4-3

[A] 678	[B] 847.5	[C] 847.5	[D] 75
[E] 4/0	[F] 230	[G] 920	[H] 920
[I] 900	[J] 900		

Figure 4-4

[A] 600	[B] 10	[C] 60	[D] 6
[E] 65	[F] 60	[G] 60	[H] 60
[I] 60			

Figure 4-5

[A] 1/3	[B] 600	[C] 200	[D] 200
[E] 3/0	[F] 3/0	[G] 200	[H] 200

Figure 4-6

[A] 480	[B] 208	[C] 1/3	[D] 250
[E] 192	[F] 192	[G] 3/0	[H] 200
[I] 200	[J] 200		

Figure 4-7

[A] 1/3	[B] 450	[C] 150	[D] 150
[E] 1/0	[F] 150	[G] 150	[H] 150

Figure 4-9

[A] 1000	[B] 10	[C] 100	[D] 3
[E] 100	[F] 100	[G] 100	[H] 100
[I] 100			

Figure 4-11

[A] 200	[B] 208	[C] 555	[D] 500
[E] 500			

Figure 4-13

[A] 15	[B] 125	[C] 18.75	[D] 18.75
[E] 20	[F] 20		

Figure 4-14

[A] 65	[B] 300	[C] 65	[D] 300
[E] 195	[F] 195	[G] 200	[H] 175
[I] 200	[J] 175	[K] 200	

Figure 4-15

[A] 68	[B] 68	[C] 250	[D] 170
[E] 170	[F] 175	[G] 175	

Figure 4-16

[A] 19	[B] 175	[C] 1.5	[D] 34.75
[E] 34.75	[F] 30	[G] 19	[H] 225
[I] 1.5	[J] 44.25	[K] 44.25	[L] 40
[M] 30	[N] 40		

Figure 4-17(A)

[A] 120	[B] 240	[C] .5	[D] 200
[E] 100	[F] 100		

Figure 4-17(b)

[A] 240	[B] 480	[C] .5	[D] 400
[E] 200	[F] 200		

Figure 4-18(a)

[A] 68	[B] 71	[C] 68	[D] 71
[E] 48.28	[F] 48.28	[G] 8	[H] 200
[I] 50	[J] 200	[K] 100	[L] 100
[M] 100	[N] 8	[O] 50	[P] 50
[Q] 200	[R] 100	[S] 100	[T] 100
[U] 100	[V] 8		

Figure 4-18(b)

[A] 76	[B] 200	[C] 76	[D] 200
[E] 152	[F] 152	[G] 175	[H] 175

Figure 4-18(c)

[A] 91	[B] 63	[C] 91	[D] 63
[E] 57.33	[F] 57.33	[G] 6	[H] 300
[I] 91	[J] 300	[K] 273	[L] 273
[M] 250	[N] 6	[O] 65	[P] 65
[Q] 300	[R] 195	[S] 195	[T] 175
[U] 175			

Figure 4-19(a)

[A] 25	[B] 25	[C] 400	[D] 100
[E] 100			

Figure 4-19(b)

[A] 20 [B] 15 [C] 300 [D] 45
[E] 45

Figure 4-19(c)
[A] 2200 [B] 480 [C] 4.58 [D] 4.58
[E] 167 [F] 7.6 [G] 7.6 [H] 6
[I] 6

Figure 4-19(d)
[A] 240 [B] 480 [C] 20 [D] 10
[E] 10 [F] 10 [G] 10

Figure 4-20
[A] 7 [B] 10 [C] 7 [D] 6
[E] 10 [F] 10 [G] 6 [H] 10

Figure 4-29(a)
[A] 200 [B] 200 [C] 600 [D] 1200
[E] 1200

Figure 4-29(b)
[A] 200 [B] 200 [C] 300 [D] 600
[E] 600

Figure 4-30
[A] 60 [B] 75 [C] 100 [D] 60
[E] 75 [F] 100 [G] 110 [H] 1
[I] 110 [J] 60

Figure 4-31
[A] 75 [B] 75 [C] 200 [D] 75
[E] 75 [F] 200 [G] 200 [H] 3/0
[I] 200 [J] 75

Figure 4-32
[A] 30 [B] 80 [C] 30 [D] 80
[E] 24 [F] 24

Figure 4-33
[A] 55 [B] 76 [C] 55 [D] 76
[E] 41.8 [F] 41.8

Figure 4-34
[A] 30 [B] 70 [C] 91 [D] 30
[E] 70 [F] 91 [G] 19.11 [H] 19.11

Figure 4-35
[A] 30 [B] 60 [C] 30 [D] 60
[E] 18 [F] 18

Figure 4-36
[A] 28 [B] 20 [C] 84 [D] 84
[E] 70 [F] 30 [G] 17.64 [H] 20
[I] 17.64

Figure 4-37
[A] 74 [B] 125 [C] 92.5 [D] 62
[E] 100 [F] 62 [G] 154.5 [H] 154.5
[I] 2/0 [J] 2/0

Figure 4-38
[A] 40 [B] 125 [C] 50 [D] 150
[E] 100 [F] 150 [G] 200 [H] 200
[I] 3/0 [J] 3/0

Figure 4-39
[A] 10 [B] 125 [C] 12.5 [D] 27
[E] 100 [F] 27 [G] 39.5 [H] 39.5
[I] 8 [J] 8

Figure 4-40
[A] 182 [B] 125 [C] 227.5 [D] 227.5
[E] 75 [F] 227.5 [G] 4/0 [H] 4/0
[I] 230 [J] 230 [K] 250 [L] 4/0
[M] 250

Figure 4-41
[A] 758 [B] 125 [C] 947.5 [D] 947.5
[E] 75 [F] 250 [G] 255 [H] 1020
[I] 1020 [J] 1000 [K] 250 [L] 1000

Figure 4-42
[A] 600 [B] 10 [C] 60 [D] 6
[E] 65 [F] 65 [G] 60 [H] 6

Figure 4-43
[A] 1/3 [B] 600 [C] 200 [D] 200
[E] 3/0 [F] 3/0

Figure 4-44
[A] 1/3 [B] 300 [C] 100 [D] 100
[E] 1 [F] 480 [G] 208 [H] 1/3

[I] 300	[J] 231	[K] 231	[L] 350
[M] 1	[N] 350		

Figure 4-45

[A] 1/3	[B] 400	[C] 133.3	[D] 133.3
[E] 1/0	[F] 1/0		

Figure 4-46

[A] 900	[B] 1/3	[C] 300	[D] 300
[E] 300	[F] 300	[G] 300	

Figure 4-47

[A] 800	[B] 10	[C] 80	[D] 4
[E] 85	[F] 85	[G] 80	[H] 4

Figure 4-48

[A] 70	[B] 480	[C] 1.732	[D] 84
[E] 84	[F] 125	[G] 105	[H] 105
[I] 110	[J] 70	[K] 208	[L] 1.732
[M] 194	[N] 194	[O] 3/0	[P] 3/0
[Q] 200	[R] 200	[S] 194	[T] 3/0

Figure 4-49

[A] 200	[B] 208	[C] 1.732	[D] 555
[E] 555	[F] 694	[G] 694	[H] 700
[I] 700	[J] 2/0		

Figure 4-50

[A] 750	[B] 480	[C] 1.732	[D] 902
[E] 902	[F] 1123	[G] 1000	[H] 1000
[I] 350			

Figure 4-51

[A] 225	[B] 480	[C] 1.732	[D] 270.6
[E] 270.6	[F] 115	[G] 311	[H] 311
[I] 400	[J] 400		

Figure 4-52

[A] 89	[B] 89	[C] 89	[D] 89
[E] 79.21	[F] 79.21	[G] 4	[H] 4

Figure 4-53

[A] 65	[B] 91	[C] 65	[D] 91
[E] 59.15	[F] 59.15	[G] 6	[H] 6

Figure 4-54

[A] 100	[B] 63	[C] 100	[D] 63
[E] 63	[F] 63	[G] 6	[H] 6

Figure 4-55

[A] 18	[B] 20	[C] 12	[D] 18
[E] 20	[F] 12		

Figure 4-56

[A] 16	[B] 100	[C] 20	[D] 16
[E] 20			

Chapter 5
Raceways, Gutters, Wireways, and Boxes
(Exercise Problems)

Figure 5-9

[A] 2	[B] 2	[C] 1	[D] 1
[E] 1	[F] 0	[G] 0	[H] 7
[I] 4	[J] 2-1/8	[K] 4	[L] 2-1/8

Figure 5-10

[A] 2.25	[B] 2.25	[C] 2.25	[D] 3.5
[E] 0	[F] 10.25	[G] 4	[H] 1-1/4
[I] 4	[J] 1-1/4		

Figure 5-11

[A] 4	[B] 4	[C] 1	[D] 1
[E] 10	[F] 4-11/16	[G] 1-1/4	[H] 4-11/16
[I] 1-1/4			

Figure 5-12

[A] 4.5	[B] 4.5	[C] 2.25	[D] 4
[E] 4	[F] 0	[G] 2.25	[H] 21.5
[I] 4-11/16	[J] 1-1/4	[K] 4-11/16	[L] 1-1/4

Figure 5-13

[A] 2	[B] 2	[C] 1	[D] 2
[E] 0	[F] 0	[G] 7	[H] 3
[I] 3	[J] 3-1/2	[K] 3	[L] 2
[M] 3-1/2			

Figure 5-14

[A] 2	[B] 2	[C] 2.25	[D] 2.25
[E] 2.25	[F] 4.5	[G] 0	[H] 15.25
[I] 3	[J] 2	[K] 3-1/2	[L] 3

[M] 2 [N] 3-1/2

Figure 5-15

[A] 18 [B] 18 [C] 18 [D] 18
[E] 9 [F] 9 [G] 90 [H] 6
[I] 4 [J] 4 [K] 6 [L] 4
[M] 4

Figure 5-16

[A] 20 [B] 20 [C] 30 [D] 30
[E] 27 [F] 27 [G] 25 [H] 25
[I] 204 [J] 6 [K] 6 [L] 6
[M] 6 [N] 6 [O] 6

Figure 5-18

[A] .864 [B] .864 [C] 1.728 [D] 1.728

Figure 5-19(a)

[A] 8 [B] 3 [C] 8 [D] 24
[E] 24 [F] 24

Figure 5-19(b)

[A] 8 [B] 4 [C] 8 [D] 32
[E] 0 [F] 0 [G] 32 [H] 32
[I] 32

Figure 5-20(a)

[A] 6 [B] 3 [C] 6 [D] 18
[E] 18 [F] 18 [G] 18 [H] 18

Figure 5-20(b)

[A] 6 [B] 3.5 [C] 6 [D] 21
[E] 2 [F] 1 [G] 24 [H] 24
[I] 24 [J] 24 [K] 24

Figure 5-21

[A] 6 [B] 3/4 [C] 3/4

Figure 5-22

[A] 14 [B] 12 [C] 10 [D] 12
[E] .1164 [F] 4 [G] .0532 [H] 4
[I] .0844 [J] .254 [K] 1 [L] 1

Figure 5-23

[A] 12 [B] 14 [C] 10 [D] 8
[E] 9 [F] .1197 [G] 9 [H] .0873
[I] 12 [J] .2532 [K] 14 [L] .5124
[M] .9726 [N] 1-1/2 [O] 1.221 [P] 1-1/2
[Q] 1-1/2

Figure 5-24

[A] 250 [B] 4/0 [C] 1/0 [D] 3
[E] 1.191 [F] 3 [G] .9711 [H] 3
[I] .5565 [J] 2.7186 [K] 2.7186 [L] 13.593
[M] 4 x 4 [N] 16 [O] 4 [P] 4

Figure 5-26

[A] 300 [B] 1000 [C] 14 [D] 6.4512
[E] 10 [F] 13.478 [G] 19.9292 [H] 26
[I] 24

Chapter 6
Feeders and Branch Circuits
(Exercise Problems)

Figure 6-1

[A] 1920 [B] 120 [C] 16 [D] 16
[E] 10,400 [F] 208 [G] 50 [H] 50
[I] 10,800 [J] 360 [K] 30 [L] 30

Figure 6-3

[A] 95 [B] 95 [C] 98 [D] 122.5
[E] 217.5 [F] 217.5

Figure 6-5(a)

[A] 3 [B] .245 [C] 200 [D] 80
[E] 7.84 [F] 240 [G] 7.2 [H] 7.84
[I] 240 [J] .0327 or 3.27 [K] .194 [L] 200
[M] 80 [N] 6.21 [O] 6.21 [P] 240
[Q] .0259 or 2.59 [R] 2.59

Figure 6-5(b)

[A] 3 [B] 12 [C] 125 [D] 82.5
[E] 34,375 [F] 4 [G] 4

Figure 6-6

[A] 3 [B] .245 [C] 200 [D] 80
[E] 7.84 [F] 6.79 [G] 240 [H] 7.2
[I] 6.79 [J] 240 [K] .0283 or 2.83 [L] 2.83

Chapter 7
Generators and Transformers

Figure 7-17

[A] 1000 [B] 12,470 [C] 1.732 [D] 46.3
[E] 46.3 [F] 300 [G] 138.9 [H] 138.9
[I] 150 [J] 46.3 [K] 250 [L] 115.75
[M] 115.75 [N] 125 [O] 150 [P] 125

Figure 7-18

[A] 500 [B] 4160 [C] 1.732 [D] 69.4
[E] 69.4 [F] 600 [G] 416.4 [H] 416.4
[I] 450 [J] 500 [K] 480 [L] 1.732
[M] 601.4 [N] 601.4 [O] 125 [P] 752

[Q] 752	[R] 800	[S] 450	[T] 800

Figure 7-19

[A] 500	[B] 4160	[C] 1.732	[D] 69.4
[E] 69.4	[F] 600	[G] 416.4	[H] 416.4
[I] 400	[J] 500	[K] 480	[L] 1.732
[M] 601.4	[N] 601.4	[O] 250	[P] 1504
[Q] 1504	[R] 1500	[S] 400	[T] 1500

Figure 7-20(a)

[A] 120	[B] 240	[C] 100	[D] 50
[E] 50			

Figure 7-20(b)

[A] 240	[B] 480	[C] 400	[D] 200
[E] 200			

Figure 7-21

[A] 50	[B] 480	[C] 1.732	[D] 60
[E] 60	[F] 125	[G] 75	[H] 75
[I] 70	[J] 70		

Figure 7-22(a)

[A] 50	[B] 480	[C] 1.732	[D] 60
[E] 60	[F] 125	[G] 75	[H] 75
[I] 80	[J] 80		

Figure 7-22(b)

[A] 3	[B] 480	[C] 6.25	[D] 6.25
[E] 167	[F] 10.44	[G] 10.44	[H] 10
[I] 10			

Figure 7-22(c)

[A] .8	[B] 480	[C] 1.67	[D] 1.67
[E] 300	[F] 5.01	[G] 5.01	[H] 3
[I] 1.67	[J] 500	[K] 8.35	[L] 8.35
[M] 6	[N] 3	[O] 6	

Figure 7-23

[A] 50	[B] 480	[C] 1.732	[D] 60.1
[E] 60.1	[F] 250	[G] 150.25	[H] 150.25
[I] 150	[J] 50	[K] 208	[L] 1.732
[M] 138.8	[N] 138.8	[O] 125	[P] 173.5
[Q] 173.5	[R] 175	[S] 150	[T] 175

Chapter 8
Motors and Compressors

(Exercise Problems)

Figure 8-1

[A] 13.2	[B] 13.2	[C] 125	[D] 16.5
[E] 16.5	[F] 14	[G] 14	

Figure 8-2

[A] 52	[B] 52	[C] 125	[D] 65
[E] 65	[F] 6	[G] 6	

Figure 8-3

[A] 45	[B] 45	[C] 125	[D] 56.25
[E] 56.25	[F] 6	[G] 6	[H] 27
[I] 35	[J] 45	[K] 27	[L] 125
[M] 33.75	[N] 35	[O] 125	[P] 43.75
[Q] 45	[R] 125	[S] 56.25	[T] 33.75
[U] 10	[V] 43.75	[W] 8	[X] 56.25
[Y] 6	[Z] 10	[AA] 8	[BB] 6

Figure 8-4

[A] 52	[B] 125	[C] 65	[D] 52
[E] 58	[F] 125	[G] 37.7	[H] 65
[I] 6	[J] 37.7	[K] 8	[L] 6
[M] 8			

Figure 8-5

[A] 124	[B] 124	[C] 85	[D] 105.4
[E] 105.4	[F] 2	[G] 2	

Figure 8-6

[A] 118	[B] 125	[C] 147.5	[D] 147.5
[E] 1/0	[F] 1/0		

Figure 8-7

[A] 104	[B] 104	[C] 125	[D] 130
[E] 130	[F] 1	[G] 1	

Figure 8-8

[A] 52	[B] 65	[C] 77	[D] 77
[E] 125	[F] 96.25	[G] 65	[H] 100
[I] 65	[J] 52	[K] 100	[L] 52
[M] 213.25	[N] 213.25	[O] 4/0	[P] 4/0

Figure 8-9

[A] 52	[B] 65	[C] 77	[D] 77
[E] 125	[F] 96.25	[G] 65	[H] 85
[I] 55.25	[J] 52	[K] 85	[L] 44.2
[M] 195.7	[N] 195.7	[O] 3/0	[P] 3/0

Figure 8-10(a)

[A] 40 [B] 125 [C] 50 [D] 37.5
[E] 100 [F] 37.5 [G] 30 [H] 125
[I] 37.5 [J] 42 [K] 100 [L] 42
[M] 28 [N] 100 [O] 28 [P] 24
[Q] 100 [R] 24 [S] 16 [T] 100
[U] 16 [V] 28 [W] 25 [X] 7
[Y] 242 [Z] 242 [AA] 250 [BB] 250

Figure 8-10(b)

[A] 28 [B] 250 [C] 70 [D] 24
[E] 100 [F] 24 [G] 16 [H] 100
[I] 16 [J] 40 [K] 125 [L] 50
[M] 37.5 [N] 100 [O] 37.5 [P] 30
[Q] 125 [R] 37.5 [S] 42 [T] 100
[U] 42 [V] 277 [W] 250 [X] 277
[Y] 250

Figure 8-10(c)

[A] 40 [B] 125 [C] 50 [D] 37.5
[E] 100 [F] 37.5 [G] 30 [H] 125
[I] 37.5 [J] 42 [K] 100 [L] 42
[M] 28 [N] 100 [O] 28 [P] 24
[Q] 100 [R] 24 [S] 16 [T] 100
[U] 16 [V] 28 [W] 25 [X] 7
[Y] 242 [Z] 242 [AA] 250 [BB] 250

Figure 8-10(d)

[A] 40 [B] 100 [C] 40 [D] 37.5
[E] 100 [F] 37.5 [G] 30 [H] 100
[I] 30 [J] 24 [K] 100 [L] 24
[M] 16 [N] 100 [O] 16 [P] 24
[Q] 25 [R] 6 [S] 153.5 [T] 153.5
[U] 2/0 [V] 2/0

Figure 8-17

[A] 80 [B] 400 [C] 400

Figure 8-18

[A] 110 [B] 550 [C] 550

Figure 8-19

[A] 200 [B] 1000 [C] 1000

Figure 8-20

[A] 350 [B] 1050 [C] 1050

Figure 8-21(a)

[A] 65 [B] 300 [C] 65 [D] 300
[E] 195 [F] 195 [G] 200 [H] 175
[I] 200 [J] 175 [K] 200

Figure 8-21(b)

[A] 65 [B] 175 [C] 65 [D] 175
[E] 113.75 [F] 113.75 [G] 125 [H] 110
[I] 125 [J] 110 [K] 125

Figure 8-21(c)

[A] 65 [B] 1100 [C] 65 [D] 1100
[E] 715 [F] 65 [G] 1700 [H] 1105
[I] 715 [J] 1105 [K] 715 [L] 1105

Figure 8-21(d)

[A] 65 [B] 250 [C] 65 [D] 250
[E] 162.5 [F] 162.5 [G] 175 [H] 150
[I] 175 [J] 150 [K] 175

Figure 8-22

[A] 65 [B] 400 [C] 65 [D] 400
[E] 260 [F] 250 [G] 250

Figure 8-23

[A] 65 [B] 225 [C] 65 [D] 225
[E] 146.25 [F] 125 [G] 125

Figure 8-24

[A] 65 [B] 400 [C] 65 [D] 400
[E] 260 [F] 250 [G] 250

Figure 8-26

[A] 21 [B] 27 [C] 34 [D] 52
[E] 52 [F] 250 [G] 130 [H] 150
[I] 34 [J] 27 [K] 21 [L] 232
[M] 232 [N] 225 [O] 225

Figure 8-27

[A] 1.1 [B] 1.6 [C] 2.1 [D] 1.1
[E] 6.6 [F] 1.6 [G] 4.8 [H] 2.1
[I] 4.2 [J] 15.6 [K] 20 [L] 16
[M] 16 [N] 15.6 [O] 20

Figure 8-28

[A] 2.2 [B] 2.9 [C] 2.9 [D] 3.6

[E] 2.2 [F] 2.2 [G] 2.9 [H] 2.9
[I] 2.9 [J] 2.9 [K] 3.6 [L] 3.6
[M] 11.6 [N] 15 [O] 80 [P] 12
[Q] 11.6 [R] 12 [S] 2.2 [T] 250
[U] 5.5 [V] 5.5 [W] 15 [X] 15

Figure 8-30
[A] 62 [B] 125 [C] 125 [D] 62
[E] 125 [F] 77.5 [G] 77.5 [H] 70
[I] 77.5

Figure 8-31
[A] 62 [B] 140 [C] 140 [D] 62
[E] 140 [F] 86.8 [G] 86.8

Figure 8-32
[A] 15 [B] 100 [C] 100

Figure 8-38
[A] 150 [B] 150 [C] 150

Figure 8-43
[A] 10 [B] 10 [C] 10

Figure 8-49
[A] 80 [B] 80 [C] 14 [D] 14
[E] 25 [F] 400 [G] 100 [H] 100
[I] 14 [J] 80 [K] 14 [L] 14
[M] 80

Figure 8-50
[A] 50 [B] 50 [C] 12 [D] 12
[E] 20 [F] 20 [G] 300 [H] 60
[I] 60 [J] 12 [K] 12 [L] 50

Figure 8-51
[A] 1.5 [B] 500 [C] 7.5 [D] 25
[E] 25 [F] 7.5 [G] 14

Figure 8-52
[A] 25 [B] 25 [C] 400 [D] 100
[E] 100

Figure 8-53
[A] 20 [B] 15 [C] 300 [D] 45
[E] 45

Figure 8-54
[A] 2200 [B] 480 [C] 4.6 [D] 17.5
[E] 167 [F] 7.68 [G] 7.68 [H] 6
[I] 6

Figure 8-55
[A] 240 [B] 480 [C] 35 [D] 17.5
[E] 17.5 [F] 15 [G] 15

Figure 8-57
[A] 200 [B] 1/3 [C] 66.7 [D] 66.7
[E] 4 [F] 25 [G] 208 [H] 1.732
[I] 69.4 [J] 69.4 [K] 135 [L] 93.7
[M] 93.7 [N] 3 [O] 3

Figure 8-60
[A] 20 [B] 10 [C] 2 [D] 2

Figure 8-62
[A] 40 [B] 52 [C] 52 [D] 40
[E] 1.3 [F] 1.3 [G] 45 [H] 58.5
[I] 58.5

Figure 8-64
[A] 29 [B] 2.5 [C] 115 [D] 36.2
[E] 36.2 [F] 40 [G] 36.2 [H] 60
[I] 40 [J] 60 [K] 31.5 [L] 25
[M] 180 [N] 25 [O] 25

Figure 8-65
[A] 30 [B] 15 [C] 200 [D] 15
[E] 25 [F] 10 [G] 160 [H] 10
[I] 20 [J] 7 1/2 [K] 140 [L] 10
[M] 75 [N] 32.5 [O] 500 [P] 32.5
[Q] 75 [R] 32.5 [S] 500 [T] 35
[U] 35 [V] 500

Figure 8-66
[A] 10 [B] 28 [C] 28 [D] 115
[E] 32.2 [F] 32.2 [G] 35 [H] 35

Figure 8-67
[A] 42 [B] 15 [C] 232 [D] 15
[E] 25 [F] 10 [G] 160 [H] 10
[I] 20 [J] 7-1/2 [K] 140 [L] 10
[M] 87 [N] 32.5 [O] 532 [P] 35
[Q] 35 [R] 35

Figure 8-69
[A] 19 [B] 175 [C] 1.5 [D] 34.75
[E] 34.75 [F] 30 [G] 19 [H] 225

[I] 1.5 [J] 44.25 [K] 44.25 [L] 40
[M] 30 [N] 40

Figure 8-70
[A] 34 [B] 175 [C] 2.5 [D] 62
[E] 62 [F] 25 [G] 2.5 [H] 23
[I] 2.4 [J] 115 [K] 115 [L] 110
[M] 110

Figure 8-71
[A] 34 [B] 225 [C] 2.5 [D] 79
[E] 79 [F] 25 [G] 2.5 [H] 23
[I] 2.5 [J] 132 [K] 132 [L] 125
[M] 125

Figure 8-72
[A] 15 [B] 46.2 [C] 46.2 [D] 250
[E] 115.5 [F] 115.5 [G] 125 [H] 25
[I] 23 [J] 173 [K] 173 [L] 150
[M] 150

Figure 8-75
[A] 19 [B] 125 [C] 23.75 [D] 2.5
[E] 100 [F] 2.5 [G] 26.25 [H] 26.25
[I] 10 [J] 10

Figure 8-76
[A] 40 [B] 125 [C] 3 [D] 53
[E] 25 [F] 100 [G] 2.5 [H] 27.5
[I] 23 [J] 100 [K] 2.5 [L] 25.5
[M] 106 [N] 106 [O] 2 [P] 2

Figure 8.77
[A] 30.5 [B] 7-1/2 [C] 7-1/2 [D] 240
[E] 7-1/2 [F] 7-1/2

Figure 8-78
[A] 19 [B] 140 [C] 26.6 [D] 19
[E] 125 [F] 23.75 [G] 26.6 [H] 23.75

Figure 8-81
[A] 10 [B] 30 [C] 30 [D] 80
[E] 24 [F] 24

Chapter 9
Residential Calculations
Single-Family Dwellings

Figure 9-1
[A] 3500 [B] 10,500 [C] 1500 [D] 3000
[E] 1500 [F] 1500 [G] 10,500 [H] 4500
[I] 15,000 [J] 3000 [K] 12,000 [L] 4200
[M] 7200 [N] 7200

Figure 9-2
[A] 3 [B] 75% [C] 4.5 [D] 4.5
[E] 4500 [F] 4500

Figure 9-3
[A] 8 [B] 65 [C] 10.4 [D] 4.5
[E] 10,400 [F] 10,400

Figure 9-4
[A] 8 [B] 8 [C] 8000 [D] 8000

Figure 9-5
[A] 16 [B] 4 [C] 4 [D] 20
[E] 8 [F] 120 [G] 9600 [H] 9600

Figure 9-6
[A] 54 [B] 54 [C] 18 [D] 18
[E] 6 [F] 6 [G] 30 [H] 14
[I] 130 [J] 18,200 [K] 18,200

Figure 9-7
[A] 30 [B] 30 [C] 18 [D] 18
[E] 90 [F] 8 [G] 190 [H] 15,200
[I] 15,200

Figure 9-8
[A] 6000 [B] 1000 [C] 1200 [D] 1400
[E] 1400 [F] 11,000 [G] 11,000 [H] 75
[I] 8250 [J] 8250

Figure 9-9
[A] 5.5 [B] 5.5 [C] 100 [D] 5500
[E] 5500

Figure 9-10
[A] 20 [B] 100 [C] 20,000 [D] 2.5
[E] 100 [F] 2500 [G] 20,000 [H] 20,000

Figure 9-11
[A] 28 [B] 28 [C] 25 [D] 7
[E] 7 [F] 1680 [G] 1680

Design exercise problem 9-1

[A] 8400	[B] 3000	[C] 1500	[D] 12,900
[E] 3465	[F] 6465	[G] 0	[H] 0
[I] 5000	[J] 3500	[K] 1050	[L] 900
[M] 1050	[N] 1200	[O] 900	[P] 750
[Q] 4500	[R] 10,350	[S] 1050	[T] 900
[U] 1050	[V] 1200	[W] 4200	[X] 6000
[Y] 1500	[Z] 350	[AA] 6465	[BB] 0
[CC] 5000	[DD] 10,350	[EE] 6000	[FF] 1500
[GG] 29,315	[HH] 6465	[II] 0	[JJ] 3500
[KK] 4200	[LL] 350	[MM] 14,515	[NN] 29,315
[OO] 122	[PP] 14,515	[QQ] 60	[RR] 1
[SS] 2	[TT] 6		

Design exercise problem 9-2

[A] 8400	[B] 3000	[C] 1500	[D] 12,900
[E] 3465	[F] 6465	[G] 11,000	[H] 7700
[I] 5000	[J] 3500	[K] 1050	[L] 900
[M] 1050	[N] 1200	[O] 900	[P] 750
[Q] 4500	[R] 10,350	[S] 1050	[T] 900
[U] 1050	[V] 1200	[W] 4200	[X] 20,000
[Y] 350	[Z] 350	[AA] 6465	[BB] 11,000
[CC] 5000	[DD] 10,350	[EE] 20,000	[FF] 350
[GG] 53,165	[HH] 6465	[II] 7700	[JJ] 3500
[KK] 4200	[LL] 350	[MM] 22,215	[NN] 53,165
[OO] 222	[PP] 22,215	[QQ] 93	[RR] 4/0
[SS] 3/0	[TT] 3		

Design exercise problem 9-3

[A] 8400	[B] 3000	[C] 1500	[D] 12,900
[E] 3465	[F] 6465	[G] 11,000	[H] 7700
[I] 5000	[J] 3500	[K] 1050	[L] 900
[M] 1050	[N] 1200	[O] 900	[P] 750
[Q] 4500	[R] 10,350	[S] 1050	[T] 900
[U] 1050	[V] 1200	[W] 4200	[X] 26,000
[Y] 1500	[Z] 350	[AA] 6465	[BB] 11,000
[CC] 5000	[DD] 10,350	[EE] 26,000	[FF] 1500
[GG] 60,315	[HH] 6465	[II] 7700	[JJ] 3500
[KK] 4200	[LL] 350	[MM] 22,215	[NN] 60,315
[OO] 251	[PP] 22,215	[QQ] 93	[RR] 250
[SS] 250	[TT] 3		

Design exercise problem 9-4

[A] 8400	[B] 3000	[C] 1500	[D] 12,900
[E] 3465	[F] 6465	[G] 11,000	[H] 7700
[I] 5000	[J] 3500	[K] 1050	[L] 900
[M] 1050	[N] 1200	[O] 900	[P] 750
[Q] 4500	[R] 10,350	[S] 1050	[T] 900
[U] 1050	[V] 1200	[W] 4200	[X] 20,000
[Y] 420	[Z] 420	[AA] 6465	[BB] 11,000
[CC] 5000	[DD] 10,350	[EE] 20,000	[FF] 420
[GG] 53,235	[HH] 6465	[II] 7700	[JJ] 3500
[KK] 4200	[LL] 420	[MM] 22,285	[NN] 53,235
[OO] 222	[PP] 22,285	[QQ] 93	[RR] 4/0
[SS] 3/0	[TT] 3		

Design exercise problem 9-5

[A] 2800	[B] 3	[C] 8400	[D] 1500
[E] 3000	[F] 1500	[G] 1500	[H] 8400
[I] 3000	[J] 1500	[K] 12,900	[L] 3000
[M] 3000	[N] 9900	[O] 35	[P] 3465
[Q] 6465	[R] 6465	[S] 6465	[T] 6465
[U] 11,000	[V] 11,000	[W] 11,000	[X] 11,000
[Y] 70	[Z] 7700	[AA] 7700	[BB] 75
[CC] 1050	[DD] 1050	[EE] 1050	[FF] 75
[GG] 900	[HH] 900	[II] 900	[JJ] 75
[KK] 1050	[LL] 1050	[MM] 1050	[NN] 75
[OO] 1200	[PP] 1200	[QQ] 1200	[RR] 75
[SS] 900	[TT] 900	[UU] 900	[VV] 75
[WW] 750	[XX] 750	[YY] 750	[ZZ] 75
[AAA] 4500	[BBB] 4500	[CCC] 4500	[DDD] 5000
[EEE] 5000	[FFF] 5000	[GGG] 5000	[HHH] 5000
[III] 70	[JJJ] 3500	[KKK] 3500	[LLL] 20,000
[MMM] 20,000	[NNN] 20,000	[OOO] 20,000	[PPP] 1400
[QQQ] 25	[RRR] 350	[SSS] 350	[TTT] 350
[UUU] 51,215	[VVV] 50,565	[WWW] 22,215	

Design exercise problem 9-6

[A] 2800	[B] 3	[C] 8400	[D] 1500
[E] 3000	[F] 1500	[G] 1500	[H] 8400
[I] 3000	[J] 1500	[K] 12,900	[L] 3000
[M] 3000	[N] 9900	[O] 35	[P] 3465
[Q] 6465	[R] 6465	[S] 240	[T] 26.94
[U] 26.94	[V] 26.94	[W] 26.94	[X] 11,000
[Y] 11,000	[Z] 240	[AA] 45.83	[BB] 45.83
[CC] 45.83	[DD] 11,000	[EE] 70	[FF] 7700
[GG] 7700	[HH] 240	[II] 32.08	[JJ] 32.08
[KK] 120	[LL] 8.75	[MM] 8.75	[NN] 8.75
[OO] 120	[PP] 7.50	[QQ] 7.50	[RR] 7.50
[SS] 120	[TT] 8.75	[UU] 8.75	[VV] 8.75
[WW] 120	[XX] 10.00	[YY] 10.00	[ZZ] 10.00
[AAA] 240	[BBB] 3.75	[CCC] 3.75	[DDD] 3.75
[EEE] 240	[FFF] 3.13	[GGG] 3.13	[HHH] 3.13
[III] 240	[JJJ] 18.75	[KKK] 18.75	[LLL] 18.75
[MMM] 5000	[NNN] 5000	[OOO] 5000	[PPP] 240

[QQQ] 20.83	[RRR] 20.83	[SSS] 20.83	[TTT] 5000
[UUU] 70	[VVV] 3500	[WWW] 3500	[XXX] 240
[YYY] 14.58	[ZZZ] 14.58	[AAAA] 20,000	[BBBB] 20,000
[CCCC] 20,000	[DDDD] 240	[EEEE] 83.33	[FFFF] 83.33
[GGGG] 83.33	[HHHH] 1400	[IIII] 25	[JJJJ] 350
[KKKK] 350	[LLLL] 120	[MMMM] 2.92	[NNNN] 2.92
[OOOO] 222.98	[PPPP] 222.06	[QQQQ] 108.60	

Design exercise problem 9-7

[A] 8400	[B] 3000	[C] 1500	[D] 9000
[E] 10,000	[F] 5000	[G] 6000	[H] 1200
[I] 1400	[J] 1600	[K] 1400	[L] 1200
[M] 1000	[N] 50,700	[O] 10,000	[P] 16,280
[Q] 26,280	[R] 13,000	[S] 6000	[T] 13,000
[U] 26,280	[V] 13,000	[W] 39,280	[X] 39,280
[Y] 164	[Z] 2/0	[AA] 4	

Design exercise problem 9-8(a)

[A] 25	[B] 65	[C] 16,250	[D] 34.5
[E] 240	[F] 100	[G] 8280	[H] 16,250

Design exercise problem 9-8(b)

[A] 4.5	[B] 5	[C] 40	[D] 9000
[E] 31.5	[F] 240	[G] 100	[H] 7560
[I] 9000			

Design exercise problem 9-9

[A] 1800	[B] 3	[C] 5400	[D] 1500
[E] 3000	[F] 1500	[G] 1500	[H] 12,000
[I] 5000	[J] 1200	[K] 1400	[L] 1600
[M] 31,100	[N] 8000	[O] 100	[P] 8000
[Q] 23,100	[R] 40	[S] 9240	[T] 17,240
[U] 6000	[V] 6000	[W] 17,240	[X] 6000
[Y] 23,240	[Z] 23,240	[AA] 240	[BB] 97
[CC] 100	[DD] 97		

Design exercise problem 9-10

[A] 1800	[B] 3	[C] 5400	[D] 1500
[E] 3000	[F] 1500	[G] 1500	[H] 12,000
[I] 5000	[J] 1200	[K] 1400	[L] 1600
[M] 31,100	[N] 8000	[O] 100	[P] 8000
[Q] 23,100	[R] 40	[S] 9240	[T] 17,240
[U] 5450	[V] 5450	[W] 17,240	[X] 5450
[Y] 22,690	[Z] 22,690	[AA] 240	[BB] 95
[CC] 100	[DD] 95		

Design exercise problem 9-11

[A] 1800	[B] 3	[C] 5400	[D] 1500
[E] 3000	[F] 1500	[G] 1500	[H] 12,000
[I] 5000	[J] 1200	[K] 1400	[L] 1600
[M] 31,100	[N] 8000	[O] 100	[P] 8000
[Q] 23,100	[R] 40	[S] 9240	[T] 17,240
[U] 1680	[V] 1680	[W] 17,240	[X] 1680
[Y] 18,920	[Z] 18,920	[AA] 240	[BB] 79
[CC] 100	[DD] 79		

Design exercise problem 9-12

[A] 2400	[B] 3000	[C] 1500	[D] 6900
[E] 1365	[F] 4365	[G] 5000	[H] 1000
[I] 540	[J] 6000	[K] 12,540	[L] 6800
[M] 4760	[N] 4365	[O] 12,540	[P] 6800
[Q] 135	[R] 23,840	[S] 23,840	[T] 99
[U] 4365	[V] 1000	[W] 540	[X] 135
[Y] 4760	[Z] 10,800	[AA] 10,800	[BB] 45
[CC] 3	[DD] 8	[EE] 4	[FF] 8

Chapter 10
Residential Calculations
Multifamily Dwellings

Figure 10-1

[A] 30	[B] 1000	[C] 3	[D] 90,000
[E] 30	[F] 1500	[G] 90,000	[H] 30
[I] 1500	[J] 45,000	[K] 90,000	[L] 90,000
[M] 45,000	[N] 225,000	[O] 3000	[P] 3000
[Q] 117,000	[R] 35	[S] 40,950	[T] 105,000
[U] 25	[V] 26,250	[W] 70,200	[X] 70,200

Figure 10-2

[A] 5	[B] 3	[C] 13,200	[D] 5
[E] 3	[F] 13,500	[G] 5	[H] 3
[I] 14,250	[J] 5	[K] 3	[L] 15,750
[M] 56,700	[N] 20	[O] 1500	[P] 60,000
[Q] 20	[R] 1500	[S] 30,000	[T] 56,700
[U] 60,000	[V] 30,000	[W] 146,700	[X] 3000
[Y] 3000	[Z] 117,000	[AA] 35	[BB] 40,950
[CC] 26,700	[DD] 25	[EE] 6675	[FF] 50,625
[GG] 50,625			

Figure 10-3

[A] 2 [B] 10 [C] 2.5 [D] 10
[E] 20 [F] 20 [G] 35 [H] 2
[I] 10 [J] 20 [K] 2.5 [L] 10
[M] 25 [N] 45 [O] 45 [P] 35
[Q] 15.75 [R] 15.75

Figure 10-4

[A] 8.5 [B] 25 [C] 8 [D] 25
[E] 50 [F] 50 [G] 30 [H] 8.5
[I] 25 [J] 212.5 [K] 8.5 [L] 25
[M] 212.5 [N] 425 [O] 425 [P] 30
[Q] 127.5 [R] 127.5

Figure 10-5

[A] 8.75 [B] 15 [C] 3 [D] 15
[E] 40 [F] 15 [G] 32 [H] 15
[I] 3 [J] 15 [K] 40 [L] 18
[M] 8.75 [N] 15 [O] 32 [P] 42
[Q] 82 [R] 82

Figure 10-6

[A] 15 [B] 30 [C] 30 [D] 15

Figure 10-7

[A] 15 [B] 30 [C] 45 [D] 45
[E] 30

Figure 10-8

[A] 25 [B] 37.5 [C] 62.5 [D] 62.5
[E] 50

Figure 10-9

[A] 18 [B] 12 [C] 6 [D] 6
[E] 5 [F] 30 [G] 14 [H] 29
[I] 29 [J] 130 [K] 37.7 [L] 37.7

Figure 10-10

[A] 12 [B] 16 [C] 18 [D] 46
[E] 46 [F] 7 [G] 322 [H] 322
[I] 21 [J] 15.3 [K] 16 [L] 12
[M] 4 [N] 4 [O] 5 [P] 20
[Q] 21 [R] 36 [S] 36 [T] 120
[U] 43.2 [V] 43.2

Figure 10-11

[A] 21 [B] 3 [C] 7 [D] 7
[E] 2 [F] 14 [G] 14 [H] 29
[I] 29 [J] 29,000 [K] 29,000 [L] 2
[M] 3 [N] 43,500 [O] 43,500

Figure 10-12

[A] 10 [B] 1000 [C] 10,000 [D] 10
[E] 1200 [F] 12,000 [G] 10 [H] 1600
[I] 16,000 [J] 10 [K] 800 [L] 8000
[M] 10 [N] 5000 [O] 50,000 [P] 96,000
[Q] 96,000 [R] 75 [S] 72,000 [T] 72,000

Figure 10-13

[A] 23 [B] 35 [C] 5000 [D] 23
[E] 35 [F] 40,250 [G] 40,250

Figure 10-14

[A] 35 [B] 42 [C] 35 [D] 9.5
[E] 25.5 [F] 42 [G] 5 [H] 25.5
[I] 53.5 [J] 42 [K] 53.5

Figure 10-15

[A] 40 [B] 3 [C] 14 [D] 14
[E] 14 [F] 2 [G] 28 [H] 28
[I] 11 [J] 17 [K] 17 [L] 85
[M] 5 [N] 28 [O] 85 [P] 119
[Q] 119 [R] 119,000 [S] 119,000 [T] 2
[U] 3 [V] 178,500 [W] 178,500

Figure 10-16

[A] 20 [B] 10 [C] 100 [D] 200
[E] 6.5 [F] 10 [G] 100 [H] 65
[I] 200

Figure 10-17

[A] 24 [B] 24 [C] 25 [D] 6
[E] 6 [F] 720 [G] 720

Design exercise problem 10-1

[A] 72,000 [B] 60,000 [C] 30,000 [D] 162,000
[E] 40,950 [F] 10,500 [G] 54,450 [H] 35,000
[I] 24,500 [J] 24,000 [K] 18,000 [L] 75,000
[M] 117,000 [N] 24,000 [O] 18,000 [P] 42,000
[Q] 400,000 [R] 300 [S] 300 [T] 54,450
[U] 35,000 [V] 117,000 [W] 400,000 [X] 300
[Y] 606,750 [Z] 54,450 [AA] 24,500 [BB] 42,000
[CC] 300 [DD] 121,250 [EE] 606,750 [FF] 2528
[GG] 121,250 [HH] 505 [II] 2528 [JJ] 421

[KK] 505	[LL] 214	[MM] 414	[NN] 414
[OO] 69	[PP] 700	[QQ] 1/0	

Design exercise problem 10-2

[A] 15,750	[B] 18,000	[C] 19,200	[D] 52,950
[E] 45,000	[F] 22,500	[G] 120,450	[H] 40,950
[I] 113	[J] 44,063	[K] 30,000	[L] 21,000
[M] 18,000	[N] 13,500	[O] 56,250	[P] 87,750
[Q] 18,000	[R] 13,500	[S] 31,500	[T] 300,000
[U] 300	[V] 300	[W] 44,063	[X] 30,000
[Y] 87,750	[Z] 300,000	[AA] 300	[BB] 462,113
[CC] 44,063	[DD] 21,000	[EE] 31,500	[FF] 300
[GG] 96,863	[HH] 462,113	[II] 1925	[JJ] 96,863
[KK] 404	[LL] 1925	[MM] 321	[NN] 404
[OO] 143	[PP] 343	[QQ] 343	[RR] 57
[SS] 400	[TT] 1/0		

Design exercise problem 10-3

[A] 15,750	[B] 18,000	[C] 19,200	[D] 52,950
[E] 45,000	[F] 22,500	[G] 120,450	[H] 40,950
[I] 113	[J] 44,063	[K] 0	[L] 18,000
[M] 13,500	[N] 56,250	[O] 87,750	[P] 18,000
[Q] 13,500	[R] 31,500	[S] 0	[T] 300
[U] 300	[V] 44,063	[W] 0	[X] 87,750
[Y] 0	[Z] 300	[AA] 132,113	[BB] 44,063
[CC] 0	[DD] 31,500	[EE] 300	[FF] 75,863
[GG] 132,113	[HH] 550	[II] 75,863	[JJ] 316
[KK] 550	[LL] 275	[MM] 316	[NN] 81
[OO] 281	[PP] 281	[QQ] 141	[RR] 300
[SS] 1/0			

Design exercise problem 10-4

[A] 15,840	[B] 24,000	[C] 12,000	[D] 51,840
[E] 17,094	[F] 20,094	[G] 23,000	[H] 16,100
[I] 9600	[J] 7200	[K] 30,000	[L] 46,800
[M] 9600	[N] 7200	[O] 16,800	[P] 80,000
[Q] 39,360	[R] 450	[S] 450	[T] 20,094
[U] 23,000	[V] 46,800	[W] 80,000	[X] 450
[Y] 170,344	[Z] 20,094	[AA] 16,100	[BB] 39,360
[CC] 16,800	[DD] 450	[EE] 92,804	[FF] 170,344
[GG] 710	[HH] 92,804	[II] 387	[JJ] 710
[KK] 237	[LL] 387	[MM] 131	[NN] 331
[OO] 331	[PP] 110	[QQ] 250	[RR] 1/0

Design exercise problem 10-5

[A] 7200	[B] 9600	[C] 12,000	[D] 6000
[E] 34,800	[F] 11,130	[G] 14,130	[H] 17,000
[I] 11,900	[J] 4800	[K] 3600	[L] 15,000
[M] 23,400	[N] 4800	[O] 3600	[P] 8400
[Q] 60,000	[R] 1250	[S] 300	[T] 14,130
[U] 17,000	[V] 23,400	[W] 60,000	[X] 1250
[Y] 115,780	[Z] 14,130	[AA] 11,900	[BB] 8400
[CC] 300	[DD] 34,730	[EE] 115,780	[FF] 482
[GG] 34,730	[HH] 145	[II] 482	[JJ] 241
[KK] 145	[LL] 73	[MM] 250	[NN] 1/0

Design exercise problem 10-6

[A] 36,000	[B] 30,000	[C] 15,000	[D] 81,000
[E] 3000	[F] 27,300	[G] 30,300	[H] 10,100
[I] 10,100	[J] 10,100	[K] 10,100	[L] 4
[M] 8	[N] 23	[O] 23,000	[P] 34,500
[Q] 11,500	[R] 11,500	[S] 11,500	[T] 8050
[U] 8050	[V] 9000	[W] 3000	[X] 3000
[Y] 3000	[Z] 3000	[AA] 12,000	[BB] 4000
[CC] 4000	[DD] 4000	[EE] 4000	[FF] 37,500
[GG] 12,500	[HH] 12,500	[II] 12,500	[JJ] 4
[KK] 8	[LL] 24	[MM] 24,000	[NN] 36,000
[OO] 12,000	[PP] 12,000	[QQ] 12,000	[RR] 18,400
[SS] 8400	[TT] 200,000	[UU] 66,667	[VV] 66,667
[WW] 66,667	[XX] 300	[YY] 300	[ZZ] 300
[AAA] 300	[BBB] 120,067	[CCC] 119,767	[DDD] 119,767
[EEE] 33,850			

Design exercise problem 10-7

[A] 36,000	[B] 30,000	[C] 15,000	[D] 81,000
[E] 3000	[F] 27,300	[G] 30,300	[H] 84
[I] 84	[J] 84	[K] 84	[L] 84
[M] 8	[N] 23	[O] 23,000	[P] 34,500
[Q] 32	[R] 32	[S] 32	[T] 22
[U] 22	[V] 9000	[W] 25	[X] 25
[Y] 25	[Z] 25	[AA] 12,000	[BB] 33
[CC] 33	[DD] 33	[EE] 33	[FF] 37,500
[GG] 35	[HH] 35	[II] 35	[JJ] 4
[KK] 8	[LL] 24	[MM] 24,000	[NN] 36,000
[OO] 33	[PP] 33	[QQ] 33	[RR] 23
[SS] 23	[TT] 200,000	[UU] 185	[VV] 185
[WW] 185	[XX] 3	[YY] 3	[ZZ] 3
[AAA] 3	[BBB] 430	[CCC] 427	[DDD] 427
[EEE] 375			

Design exercise problem 10-8

[A] 72,000	[B] 60,000	[C] 30,000	[D] 162,000
[E] 200,000	[F] 32,000	[G] 24,000	[H] 100,000
[I] 156,000	[J] 400,000	[K] 162,000	[L] 200,000
[M] 156,000	[N] 400,000	[O] 918,000	[P] 918,000
[Q] 3825	[R] 3825	[S] 1454	[T] 1454
[U] 242	[V] 250	[W] 1/0	

Design exercise problem 10-9

[A] 15,750	[B] 18,000	[C] 19,200	[D] 45,000
[E] 22,500	[F] 120,450	[G] 150,000	[H] 24,000
[I] 18,000	[J] 75,000	[K] 117,000	[L] 300,000
[M] 120,450	[N] 150,000	[O] 117,000	[P] 300,000
[Q] 687,450	[R] 687,450	[S] 2864	[T] 2864
[U] 1146	[V] 1146	[W] 191	[X] 3/0
[Y] 1/0			

Design exercise problem 10-10

[A] 39,600	[B] 19,800	[C] 19,800	[D] 45,000
[E] 22,500	[F] 22,500	[G] 22,500	[H] 11,250
[I] 11,250	[J] 39,435	[K] 150,000	[L] 150,000
[M] 150,000	[N] 21,000	[O] 21,000	[P] 10,500
[Q] 10,500	[R] 15,750	[S] 10,440	[T] 5220
[U] 5220	[V] 7830	[W] 11,475	[X] 5738
[Y] 5738	[Z] 8606	[AA] 15,000	[BB] 7500
[CC] 7500	[DD] 11,250	[EE] 13,800	[FF] 6900
[GG] 6900	[HH] 10,350	[II] 90,000	[JJ] 90,000
[KK] 90,000	[LL] 36,000	[MM] 36,000	[NN] 36,000
[OO] 12,000	[PP] 12,000	[QQ] 12,000	[RR] 75,000
[SS] 75,000	[TT] 75,000	[UU] 32,250	[VV] 150,000
[WW] 150,000	[XX] 150,000	[YY] 230	[ZZ] 602,408
[AAA] 602,408	[BBB] 146,701		

Chapter 11
Commercial Calculations

Figure 11-1

[A] 70	[B] 70	[C] 90	[D] 112.5
[E] 182.5	[F] 182.5		

Figure 11-2

[A] 6000	[B] 3	[C] 18,000	[D] 18,000

Figure 11-3

[A] 16	[B] 2880	[C] 12	[D] 1800
[E] 10	[F] 1000	[G] 5680	[H] 5680
[I] 125	[J] 7100	[K] 7100	

Figure 11-4

[A] 100	[B] 200	[C] 20,000	[D] 20,000
[E] 125	[F] 25,000	[G] 25,000	

Figure 11-5

[A] 30	[B] 2	[C] 150	[D] 2250
[E] 2250			

Figure 11-6

[A] 25	[B] 30	[C] 750	[D] 750
[E] 125	[F] 937.5	[G] 937.5	[H] 120
[I] 7.81	[J] 7.81		

Figure 11-7

[A] 50	[B] 120	[C] 6000	[D] 6000
[E] 125	[F] 7500	[G] 7500	

Figure 11-8

[A] 1200	[B] 125	[C] 1500	[D] 1500

Figure 11-9

[A] 180	[B] 40	[C] 125	[D] 9000
[E] 180	[F] 40	[G] 100	[H] 7200
[I] 9000	[J] 7200		

Figure 11-10

[A] 150	[B] 180	[C] 27,000	[D] 10,000
[E] 100	[F] 10,000	[G] 17,000	[H] 50
[I] 8500	[J] 18,500	[K] 18,500	

Figure 11-11

[A] 200	[B] 180	[C] 36,000	[D] 36,000
[E] 200	[F] 180	[G] 7200	[H] 7200

Figure 11-12(a)

[A] 13,728	[B] 125	[C] 17,160	[D] 17,160

Figure 11-12(b)

[A] 13,728	[B] 100	[C] 13,728	[D] 13,728

Figure 11-13

[A] 17,280	[B] 15,800	[C] 98,214	[D] 40,000
[E] 7200	[F] 178,494	[G} 178,494	[H] 80
[I] 142,795	[J] 142,795		

Figure 11-14

[A] 35	[B] 480	[C] 1.732	[D] 29,098
[E] 45	[F] 480	[G] 1.732	[H] 37,411
[I] 29,098	[J] 29,098	[K] 37,411	[L] 37,411
[M] 66,509	[N] 66,509		

Figure 11-15

[A] 14	[B] 27	[C] 34	[D] 40
[E] 14	[F] 14	[G] 27	[H] 27
[I] 34	[J] 34	[K] 40	[L] 40
[M] 115	[N] 115	[O] 480	[P] 1.732
[Q] 95,606	[R] 95,606		

Figure 11-16

[A] 10	[B] 100	[C] 10	[D] 5.5
[E] 100	[F] 5.5	[G] 10	

Figure 11-17

[A] 40	[B] 45	[C] 7	[D] 45
[E] 25	[F] 11.25	[G] 11.25	[H] 9349
[I] 9349			

Design exercise problem 11-1

[A] 150,000	[B] 187,500	[C] 6250	[D] 7813
[E] 20,000	[F] 7500	[G] 7200	[H] 9000
[I] 4200	[J] 5250	[K] 237,063	[L] 12,960
[M] 21,600	[N] 34,560	[O] 10,000	[P] 12,280
[Q] 22,280	[R] 6120	[S] 7650	[T] 29,930
[U] 12,000	[V] 7875	[W] 6325	[X] 9420
[Y] 35,620	[Z] 2,880	[AA] 1176	[BB] 4056
[CC] 60,000	[DD] 24,640	[EE] 2355	[FF] 237,063
[GG] 29,930	[HH] 12,000	[II] 35,620	[JJ] 4056
[KK] 60,000	[LL] 2355	[MM] 381,024	[NN] 381,024
[OO] 240	[PP] 1588	[QQ] 195,150	[RR] 28,400
[SS] 223,550	[TT] 223,550	[UU] 240	[VV] 931

Design exercise problem 11-2

A] 150,000	[B] 187,500	[C] 6250	[D] 7813
[E] 20,000	[F] 7500	[G] 7200	[H] 9000
[I] 4200	[J] 5250	[K] 237,063	[L] 12,960
[M] 21,600	[N] 34,560	[O] 10,000	[P] 12,280
[Q] 22,280	[R] 6120	[S] 7650	[T] 29,930
[U] 12,000	[V] 7875	[W] 6325	[X] 9420
[Y] 35,620	[Z] 2700	[AA] 864	[BB] 3564
[CC] 60,000	[DD] 24,640	[EE] 2355	[FF] 237,063
[GG] 29,930	[HH] 12,000	[II] 35,620	[JJ] 3564
[KK] 60,000	[LL] 2355	[MM] 376,968	[NN] 376,968
[OO] 360	[PP] 1047	[QQ] 195,150	[RR] 28,400
[SS] 223,550	[TT] 223,550	[UU] 360	[VV] 621

Design exercise problem 11-3

[A] 150,000	[B] 187,500	[C] 6250	[D] 7813
[E] 20,000	[F] 7500	[G] 7200	[H] 9000
[I] 4200	[J] 5250	[K] 237,063	[L] 12,960
[M] 21,600	[N] 34,560	[O] 10,000	[P] 12,280
[Q] 22,280	[R] 6120	[S] 7650	[T] 29,930
[U] 12,000	[V] 7875	[W] 6325	[X] 9420
[Y] 35,620	[Z] 2825	[AA] 914	[BB] 3739
[CC] 60,000	[DD] 24,640	[EE] 2355	[FF] 237,063
[GG] 29,930	[HH] 12,000	[II] 35,620	[JJ] 3739
[KK] 60,000	[LL] 2355	[MM] 380,707	[NN] 380,707
[OO] 831	[PP] 458	[QQ] 156,250	[RR] 156,250
[SS] 156,250	[TT] 831	[UU] 188	

Design exercise problem 11-4

[A] 150,000	[B] 187,500	[C] 6250	[D] 7813
[E] 20,000	[F] 7500	[G] 7200	[H] 9000
[I] 4200	[J] 5250	[K] 237,063	[L] 12,960
[M] 21,600	[N] 34,560	[O] 10,000	[P] 12,280
[Q] 22,280	[R] 6120	[S] 7650	[T] 29,930
[U] 12,000	[V] 7875	[W] 6325	[X] 9420
[Y] 35,620	[Z] 2829	[AA] 915	[BB] 3744
[CC] 60,000	[DD] 24,640	[EE] 2355	[FF] 237,063
[GG] 29,930	[HH] 266,993	[II] 12,000	[JJ] 35,620
[KK] 3744	[LL] 60,000	[MM] 2355	[NN] 101,719
[OO] 266,993	[PP] 240	[QQ] 1112	[RR] 101,719
[SS] 416	[TT] 245	[UU] 223,550	[VV] 240
[WW] 931	[XX] 1112	[YY] 245	[ZZ] 1357
[AAA] 245			

Design exercise problem 11-5

[A] 518,000	[B] 647,500	[C] 2100	[D] 2625
[E] 4800	[F] 6000	[G] 7500	[H] 3240
[I] 4050	[J] 4800	[K] 6000	[L] 672,475
[M] 35,280	[N] 31,680	[O] 66,960	[P] 10,000
[Q] 28,480	[R] 152,200	[S] 20,160	[T] 25,200

[U] 177,400 [V] 4900 [W] 6125 [X] 9600
[Y] 8250 [Z] 10,313 [AA] 1750 [BB] 2188
[CC] 2000 [DD] 2500 [EE] 30,726 [FF] 36,730
[GG] 50,000 [HH] 9183 [II] 976,514 [JJ] 976,514
[KK] 831 [LL] 1175 [MM] 518,000 [NN] 2100
[OO] 520,100 [PP] 520,100 [QQ] 831 [RR] 626

Design exercise problem 11-6

[A] 72,000 [B] 90,000 [C] 4800 [D] 6000
[E] 1250 [F] 1563 [G] 97,563 [H] 33,120
[I] 43,200 [J] 76,320 [K] 10,000 [L] 33,160
[M] 43,160 [N] 11,160 [O] 13,950 [P] 57,110
[Q] 2400 [R] 4800 [S] 5400 [T] 33,000
[U] 30,000 [V] 15,200 [W] 90,800 [X] 59,020
[Y] 15,360 [Z] 26,604 [AA] 7322 [BB] 4742
[CC] 38,668 [DD] 1830 [EE] 458 [FF] 252,819
[GG] 252,819 [HH] 831 [II] 304 [JJ] 78,050
[KK] 78,050 [LL] 78,050 [MM] 831 [NN] 94

Design exercise problem 11-7

[A] 13,600 [B] 17,000 [C] 2625 [D] 3281
[E] 3240 [F] 4050 [G] 3600 [H] 4500
[I] 28,831 [J] 5400 [K] 3600 [L] 4500
[M] 3600 [N] 13,500 [O] 4125 [P] 5680
[Q] 7200 [R] 8500 [S] 3425 [T] 2704
[U] 10,000 [V] 16,000 [W] 11,000 [X] 2912
[Y] 71,546 [Z] 46,505 [AA] 7322 [BB] 4742
[CC] 12,064 [DD] 40,000 [EE] 7200 [FF] 1800
[GG] 142,700 [HH] 23,065 [II] 12,600 [JJ] 35,665
[KK] 142,700 [LL] 360 [MM] 396 [NN] 35,665
[OO] 360 [PP] 99

Design exercise problem 11-8

[A] 118,000 [B] 20,000 [C] 13,600 [D] 33,600
[E] 10,000 [F] 7500 [G] 5400 [H] 6750
[I] 7200 [J] 9000 [K] 66,850 [L] 39,240
[M] 21,600 [N] 60,840 [O] 10,000 [P] 25,420
[Q] 35,420 [R] 17,640 [S] 22,050 [T] 57,470
[U] 11,200 [V] 14,000 [W] 12,800 [X] 16,000
[Y] 19,968 [Z] 1581 [AA] 50,000 [BB] 50,000
[CC] 151,548 [DD] 69,804 [EE] 39,888 [FF] 9141
[GG] 118,833 [HH] 200,000 [II] 2909 [JJ] 597,610
[KK] 597,610 [LL] 831 [MM] 719 [NN] 33,600
[OO] 33,600 [PP] 831 [QQ] 40

Design exercise problem 11-9

[A] 24,000 [B] 10,000 [C] 1600 [D] 11,600
[E] 3000 [F] 1875 [G] 2700 [H] 3375
[I] 5400 [J] 6750 [K] 26,600 [L] 9720
[M] 12,150 [N] 4200 [O] 5250 [P] 5900
[Q] 7375 [R] 5800 [S] 7250 [T] 24,800
[U] 31,000 [V] 21,120 [W] 48,000 [X] 23,960
[Y] 29,950 [Z] 149,945 [AA] 20,000 [BB] 240,480
[CC] 260,480 [DD] 1503 [EE] 369 [FF] 450,678
[GG] 450,678 [HH] 360 [II] 1252 [JJ] 24,575
[KK] 9720 [LL] 37,020 [MM] 369 [NN] 71,684
[OO] 71,684 [PP] 360 [QQ] 199

Design exercise problem 11-10

[A] 29,400 [B] 36,750 [C] 12,000 [D] 7500
[E] 7200 [F] 9000 [G] 1800 [H] 2250
[I] 2400 [J] 3000 [K] 70,500 [L] 16,920
[M] 10,800 [N] 27,720 [O] 10,000 [P] 8860
[Q] 18,860 [R] 8 ,640 [S] 10,800 [T] 29,660
[U] 6420 [V] 8025 [W] 28,940 [X] 36,175
[Y] 33,600 [Z] 42,000 [AA] 8000 [BB] 14,000
[CC] 108,200 [DD] 9504 [EE] 17,424 [FF] 32,400
[GG] 59,328 [HH] 50,000 [II] 2178 [JJ] 132
[KK] 319,866 [LL] 319,866 [MM] 360 [NN] 889
[OO] 60,300 [PP] 27,500 [QQ] 40,020 [RR] 9504
[SS] 132 [TT] 137,456 [UU] 137,456 [VV] 360
[WW] 382

Design exercise problem 11-11

[A] 9000 [B] 11,250 [C] 1080 [D] 1350
[E] 1200 [F] 13,800 [G] 10,800 [H] 13,500
[I] 8520 [J] 3408 [K] 13,440 [L] 11,520
[M] 11,570 [N] 8010 [O] 56,468 [P] 8712
[Q] 2376 [R] 11,088 [S] 20,000 [T] 2178
[U] 13,800 [V] 13,500 [W] 56,468 [X] 11,088
[Y] 20,000 [Z] 2178 [AA] 117,034 [BB] 117,034
[CC] 360 [DD] 325 [EE] 11,280 [FF] 10,800
[GG] 22,080 [HH] 22,080 [II] 360 [JJ] 61

Design exercise problem 11-12

[A] 40,000 [B] 6000 [C] 4000 [D] 1000
[E] 51,000 [F] 810,648 [G] 51,000 [H] 15.895058
[I] 51,000 [J] 153,000 [K] 12.895058 [L] 51,000
[M] 493,235.96 [N] 646,235.96 [O] 646,235.96

Design exercise problem 11-13

[A] 17,280	[B] 15,800	[C] 98,214	[D] 40,000
[E] 7200	[F] 178,494	[G] 178,494	[H] 80
[I] 142,795	[J] 142,795		

Design exercise problem 11-14

[A] 218	[B] 218	[C] 273	[D] 273
[E] 102	[F] 500	[G] 380	[H] 380
[I] 102			

Chapter 1
Services

1.	(b)	**230.23(B), Ex.**
2.	(b)	**230.24(B)**
3.	(d)	**230.79(C)** and **Table 310.15(B)(6)**
4.	(a)	**230.26**
5.	(a)	**230.93**
6.	(b)	**230.6(2)**
7.	(a)	**230.9**
8.	(c)	**230.72(A)** and **230.71(A)**
9.	(a)	**230.79(A)**
10.	(c)	**230.208**
11.	(d)	**230.2(C)(1)**
12.	(a)	**230.24(A)**
13.	(d)	**230.24(A), Ex. 1** and **230.24(B)(1)**
14.	(c)	**230.24(A), Ex. 3**
15.	(b)	**230.24(B)(2)**
16.	(c)	**230.24(B)(3)**
17.	(d)	**230.24(B)(4)**
18.	(b)	**230.42(B)**
19.	(a)	**230.51(B)**
20.	(c)	**230.71(A)**

Chapter 2
Switchboards and Panelboards

1.	(b)	**408.18(B)** and **110.26(F)(1)(a)**
2.	(a)	**408.22** and **250.178**
3.	(b)	**408.36(C)**
4.	(a)	**408.41**
5.	(b)	**408.40, Ex.**
6.	(c)	**408.18(A)**
7.	(b)	**Table 408.5**
8.	(b)	**408.36(A)**
9.	(c)	**408.55, 408.3(G),** and **Table 312.6(B)**
10.	(a)	**408.18(A)**

Chapter 3
Grounding and Bonding

1.	(d)	**250.34(A)(1)** and **(A)(2)**
2.	(a)	**250.32(A)** and **Ex.**
3.	(d)	**250.130(C)**
4.	(a)	**250.130(C), FPN** and **406.3(D)**
5.	(a)	**250.102(E)**
6.	(a)	**250.52(A)(1)**
7.	(d)	**250.60** and **106**
8.	(b)	**250.64(A)**
9.	(a)	**680.26(B)(5)**
10.	(a)	**250.24(C)(1)**
11.	(c)	**250.142(B), Ex. 1** and **250.140(2), Ex.**
12.	(d)	**250.28(B)**
13.	(b)	**250.102(E)**
14.	(d)	**250.92(B)**
15.	(a)	**250.52(A)(1)**
16.	(b)	**250.52(A)(1)**
17.	(b)	**250.52(A)(3)** and **250.66(B)**
18.	(a)	**250.52(A)(4)** and **250.53(F)**
19.	(c)	**250.56**
20.	(c)	**250.118(6)(d)**

Chapter 4
Overcurrent Protection Devices and Conductors

1.	(b)	**310.10, FPN**
2.	(a)	**110.14(C)(1)(a)**
3.	(a)	**310.15(B)(4)(c)**
4.	(d)	**310.15(B)(2)(a)** and **Table 310.16**
5.	(d)	**310.8(A)** and **Table 310.13**
6.	(b)	**240.24(A)**
7.	(a)	**210.19(A)(1), 215.2(A)(1),** and **230.42(A)(1)**
8.	(b)	**240.81**
9.	(a)	**240.83(D)**
10.	(c)	**230.95(C)**
11.	(c)	**Article 100**
12.	(b)	**Article 100**
13.	(b)	**310.4**
14.	(a)	**725.51(A)**
15.	(c)	**310.12(A)** and **200.6(A)** and **(B)**
16.	(a)	**240.21(B)(1)**and **(B)(2)**
17.	(a)	**240.22**
18.	(b)	**230.95(A)** and **240.13**
19.	(c)	**240.4(B)**
20.	(c)	**240.21(B)(2)**

21. Table 310.15(B)(2)(a) - (b)

Step 1: Finding adjustment factor
Table 310.15(B)(2)(a)
4 current-carrying conductors
4 requires 80% multiplier

Step 2: Finding allowable ampacity
Table 310.15(B)(2)(a)
40 A x 80% = 32 A

Solution: The allowable ampacity for each conductor is 32 amps.

22. Table 310.15(B)(2)(a) and Ambient Temperature Correction Factors to Table 310.16 - (c)

Step 1: Finding amperage of conductors
Table 310.16
10 AWG THHN cu. = 40 A

Step 2: Finding adjustment factor
Table 310.15(B)(2)(a)
8 current-carrying conductors
8 conductors requires 70% multiplier

Step 3: Finding correction factor
Correction factors to **Table 310.16**
120°F requires 82% multiplier

Step 4: Finding allowable amperage
Table 310.15(B)(2)(a) and correction factors to **Table 310.16**
40 A x 70% x 82% = 22.96 A

Solution: The allowable ampacity is 22.96 amps for each conductor.

23. 240.21(B)(1), 240.4(B) and **(E), Table 310.16,** and **240.6(A) -** (a)

Step 1: Calculating minimum size tap
240.21(B)(1)(4)
A = 400 A OCPD ÷ 10 (1/10 of OCPD)
A = 40

Step 2: Sizing conductors
Table 310.16
8 AWG THWN cu. = 50 A (75ºC column)

Step 3: Verifying size
240.21(B)(1)
50 A is greater than 40 A

Step 4: Calculating OCPD
240.4(E), 240.21(B)(1)(1)(2), and **240.4(B)**
50 A conductors permit 50 A OCPD or 45 A OCPD to protect conductors from overloads

Solution: The size THWN copper conductors is 8 AWG and the size overcurrent protection device is permitted to be 45 amps.

24. 240.21(B)(2), 240.4(B) and **(E), Table 310.16,** and **240.6(A) -** (c)

Step 1: Calculating minimum size tap
240.21(B)(2)(1)
1/3 (OCPD) x 400 A OCPD = 133 A

Step 2: Selecting conductors
Table 310.16
133 A requires 1/0 AWG cu.

Step 3: Selecting OCPD
240.4(E), 240.21(B)(2)(2), and **240.4(B)**
1/0 AWG requires 125 A OCPD

Solution: The size overcurrent protection device is 125 amps and the size THWN copper conductors are 1/0 AWG.

Chapter 5
Raceways, Gutters, Wireways, and Boxes

1.	(b)	**314.16(B)(1)**
2.	(a)	**314.16(B)(5)**
3.	(a)	**Note 4** to **Table 1, Ch. 9**
4.	(c)	**Note 4** to **Table 1, Ch. 9**
5.	(b)	**Note 4** to **Table 1, Ch. 9**
6.	(a)	**314.23(B)(1)**
7.	(a)	**314.23(E)**
8.	(b)	**314.23(F)**
9.	(a)	**320.23(A)**
10.	(b)	**334.23** and **320.23(A)**
11.	(b)	**422.18** and **314.27(D)**
12.	(d)	**314.27(B)**
13.	(c)	**344.28**
14.	(a)	**358.30(A)**
15.	(d)	**344.30(B)(1)**
16.	(b)	**348.30(A)**
17.	(a)	**300.4(A)(2)**
18.	(b)	**352.30(A)**
19.	(c)	**320.23(A)**
20.	(b)	**334.15(C)**

21. 314.16(B)(1) thru (5), Table 314.16(A), and **Table 314.16 (B) -** (d)

Step 1: Counting conductors within the box
314.16(B)(1) thru (B)(5) and **Table 314.16(B)**
(Conductor fill)
314.16(B)(1)

2 - 12 AWG hots	2.25 cu. in. x 2	= 4.5 cu. in.
2 - 12 AWG neutrals	2.25 cu. in. x 2	= 4.5 cu. in.
2 - 14 AWG hots	2.0 cu. in. x 2	= 4.0 cu. in.
2 - 14 AWG neutrals	2.0 cu. in. x 2	= 4.0 cu. in.
(EGC fill)		
314.16(B)(5)		
2 - 12 AWG EGCs	2.25 cu. in. x 1	= 2.25 cu. in.
2 - 14 AWG EGCs	2.0 cu. in. x 0	= 0
(Cable clamp fill)		
314.16(B)(2)		
2 cable clamps	2.25 cu. in. 1	= 2.25 cu. in.
Total		= 21.5 cu. in.

Step 2: Selecting octagon box
Table 314.16(A)
21.5 cu. in. requires 4" x 2-1/8" (100 mm x 54 mm)

Solution: A 4 in. x 2-1/8 in. (100 mm x 54 mm) octagon box is required.

22. 314.16(B)(1) thru (B)(5) and **Table 314.16(B) -** (b)

Step 1: Counting cu. in.of conductors
314.16(B)(1) thru (5) and **Table 314.16(B)**
(Conductor fill)

10 - 12 AWG cond.	2.25 cu. in. x 10	= 22.5 cu. in.
10 - 12 AWG cond.	2.25 cu. in. x 10	= 22.5 cu. in.
10 - 12 AWG cond.	2.25 cu. in. x 10	= 22.5 cu. in.
10 - 12 AWG cond.	2.25 cu. in. x 10	= 22.5 cu. in.
8 - 12 AWG cond.	2.25 cu. in. x 8	= 18 cu. in.
8 - 12 AWG cond.	2.25 cu. in. x 8	= 18 cu. in.
Total		= 126 cu. in.

Step 2: Selecting box
Box chart No. 1 (back inside cover of this book)
6" x 6" x 4" (200 mm x 200 mm x 100 mm) = 144 cu. in.
144 cu. in. will contain 126 cu. in.

Solution: A 6 in. x 6 in. x 4 in. (200 mm x 200 mm x 100 mm) junction box is required.

23. 314.28(A)(2) - (b)

Step 1: Finding the multiplier
314.28(A)(2)
Multiplier = 6

Step 2: Calculating length of junction box
314.28(A)(2)

3-1/2" x 6	= 21"
	= 2"
	= 1"
Total	= 24"

Solution: The minimum length is 24 in. x 24 in.

24. Tables 4 and **5, Ch. 9** and **Note 4** to **Table 1** to **Ch. 9 -** (a)

Step 1: Finding sq. in. area
Table 5, Ch. 9
14 AWG = .0097 sq. in.
12 AWG = .0133 sq. in.
10 AWG = .0211 sq. in.
8 AWG = .0366 sq. in.

Step 2: Calculating sq. in. area
Table 5, Ch. 9
.0097 sq. in. x 10 = .097 sq. in.
.0133 sq. in. x 10 = .133 sq. in.
.0211 sq. in. x 8 = .1688 sq. in.
.0366 sq. in. x 12 = .4392 sq. in.
Total = .838 sq. in.

Step 3: Finding EMT at 100% total fill
Table 4, Ch. 9
1-1/4" EMT has a 100% total of 1.496

Step 4: Applying 60% fill
Note 4 to **Table 1** to **Ch. 9**
sq. in. area x 60% = fill area
1.496 sq. in. x 60% = .8976 sq. in.

Step 5: Selecting the EMT nipple
Table 4, Ch. 9
.8976 sq. in. is greater than .838 sq. in.

Solution: A 1-1/4 in. EMT nipple is required.

25. (d) **314.16(B)(1)** and **300.14**

Chapter 6
Feeders and Branch Circuits

1. (b) **Article 100**
2. (c) **220.61(C)(2), FPN**
3. (a) **310.15(B)(4)(a)**
4. (b) **210.11(C)(1), 210.52(B),** and **220.52(A)**
5. (a) **210.11(C)(2), 210.52(F),** and **220.52(B)**
6. (b) **210.19(A)(3), Ex. 1**
7. (a) **220.54**
8. (a) **110.14(C)(1)(a)** and **(C)(1)(b)**
9. (b) **220.18(B)** and **210.19(A)(1)**
10. (b) **220.14(G)** and **220.43(A)**
11. (d) **220.54** and **Table 220.54**
12. (a) **210.23(C)**
13. (c) **210.23(C)**
14. (a) **110.14(C)(1)(b)**
15. (b) **Table 220.12**
16. (c) **210.23(B)**
17. (d) **210.23(D)**
18. (b) **110.14(C)(1)(a)**
19. (a) **210.6(A)(2)**
20. (a) **220.43(B)**

21. 210.11(A), 220.12, and **Table 220.12 - (c)**

Step 1: Finding VA per sq. ft
220.12 and **Table 220.12**
The VA per sq. ft is 3

Step 2: Finding total VA
Table 220.12
3000 sq. ft x 3 VA = 9000 VA

Step 3: Finding the number of circuits
210.11(A)
9000 VA ÷ 15 A OCPD x 120 V = 5 circuits

Solution: The number of 15 amp, two.wire circuits is 5.

22. 220.14(I), 210.19(A)(1), and **210.11(A) - (d)**

Step 1: Finding amperage of receptacle outlets
220.14(I) and **210.19(A)(1)**
A = 180 VA per receptacle x 125% ÷ 120 V
A = 1.875

Step 2: Finding number of receptacle outlets permitted
210.11(A)
= 20 A OCPD ÷ 1.875 A = 10.6 (round down)
= 10 receptacles

Solution: The number of continuous receptacle outlets permitted on a 20 amp branch circuit is 10.

23. 220.61 and **310.15(B)(4)(c) - (c)**

Step 1: Calculating neutral load
220.61 and **310.15(B)(4)(c)**
First 200 A x 100% = 200 A
Remaining 100 A x 70% = 70 A
Total = 270 A

Solution: The total resistive neutral demand load is 270 amps.

24. 215.2, FPN 2 and **Table 8, Ch. 9 - (b)**

Step 1: Selecting percentage
215.2(A), FPN 2
Feeder = 3%

Step 2: Calculating allowable VD
215.2(A), FPN 2 and **Table 8, Ch. 9**
VD = (2 x R x L x I) ÷ 1000
VD = (2 x .0766 x 300 x 180) ÷ 1000
VD = 8.2728

Step 3: Calculating allowable VD
VD = supply V x 3%
VD = 240 V x 3%
VD = 7.2 V

Step 4: Checking percentage
215.2(A), FPN 2
% = VD ÷ V
% = 8.2728 VD ÷ 240 V
% = .03447 or 3.447

Solution: The voltage rating of 8.2728 is greater than 7.2 volts and a larger conductor must be used to reduce the 3.447

percent to 3 percent or less.

Step 1: Selecting percentage
215.2(A), FPN 2
Feeder = 3%

Step 2: Calculating VD
215.2(A), FPN 2 and **Table 8, Ch. 9**
VD = (2 x R x L x I) ÷ 1000
VD = (2 x .0608 x 300 x 180) ÷ 1000
VD = 6.5664

Step 3: Checking percentage
215.2(A), FPN 2
% = 6.5664 V ÷ 240 V
% = .02736 or 2.736

Solution: The voltage drop rating of 6.5664 volts is less than 7.2 volts, which is well below the 3 percent limit. The 4/0 AWG conductors are large enough to reduce the voltage drop to 3 percent or less.

Chapter 7
Generators and Transformers

1.	(a)	**445.10** and **430.14**
2.	(d)	**445.12(A)**
3.	(c)	**445.12(D)**
4.	(d)	**445.12(A)**
5.	(a)	**445.14**
6.	(a)	**450.7**
7.	(c)	**450.13(B)**
8.	(a)	**450.42**
9.	(a)	**450.43(C)**
10.	(b)	**450.47**
11.	(c)	**445.13**
12.	(a)	**445.13, Ex.**
13.	(a)	**445.14**
14.	(b)	**450.8(C)** and **110.27(A)(4)**
15.	(c)	**450.21(C)**
16.	(c)	**450.42**
17.	(c)	**450.43(B)**
18.	(b)	**450.21(A)**
19.	(a)	**450.25**
20.	(b)	**450.42**

21. Finding amperage **- (b)**

Step 1: Finding primary amps of transformer
A = (kVA x 1000) ÷ V
A = (20 kVA x 1000) ÷ 480 V
A = 41.7

Step 2: Finding secondary amps of transformer
A = (kVA x 1000) ÷ V
A = (20 kVA x 1000) ÷ 240 V
A = 83.3

Solution: The primary amperage is 41.7 amps and the secondary amperage is 83.3 amps.

22. 450.3(A), Table 450.3(A), and **240.6(A) - (d)**

Step 1: Finding primary FLA of transformer
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (400 kVA x 1000) ÷ (4160 V x 1.732)
FLA = 55.5 A

Step 2: Calculating primary FLA for OCPD
450.3(A) and **Table 450.3(A)**
FLA = 55.5 A x 600%
FLA = 333 A

Step 3: Selecting primary OCPD
Table 450.3(A) and **240.6(A)**
333 A requires 300 A OCPD

Step 4: Finding secondary FLA of transformer
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (400 kVA x 1000) ÷ (480 V x 1.732)
FLA = 481.1 A

Step 5: Calculating secondary FLA for OCPD
450.3(A) and **Table 450.3(A)**
FLA = 481.1 A x 250%
FLA = 1203.75 A

Step 6: Selecting secondary OCPD
Table 450.3(A) and **240.6(A)**
1203.75 A permits 1200 A OCPD

Solution: The size overcurrent protection device for the primary side is 300 amps and the size overcurrent protection device for the secondary side is 1200 amps.

23. 450.3(B), Table 450.3(B), and **240.6(A) - (b)**

Step 1: Finding primary FLA
FLA = (kVA x 1000) ÷ V
FLA = (2 kVA x 1000) ÷ 480 V
FLA = 4.16 A

Step 2: Calculating OCPD
450.3(B) and **Table 450.3(B)**
4.16 A x 167% = 6.94 A

Step 3: Selecting OCPD
Table 450.3(B) and **240.6(A)**
6.94 A permits 6 A

Solution: The size overcurrent protection device in the primary side is 6 amps.

24. 450.3(B), Table 450.3(B), 430.72(C)(4), and **240.6(A) - (a)**

Step 1: Finding FLA of transformer (minimum)
FLA = (kVA x 1000) ÷ V
FLA = (.7 kVA x 1000) ÷ 480 V
FLA = 1.45 A

Step 2: Calculating OCPD (minimum)
450.3(B) and **Table 450.3(B)**
1.45 A x 300% = 4.35 A

Step 3: Selecting OCPD (minimum)
Table 450.3(B) and **240.6(A)**
4.35 A permits 3 A

Step 4: Calculating OCPD (maximum)

430.72(C)(4)
1.45 A x 500% = 7.25 A

Step 5: Selecting OCPD (maximum)
430.72(C)(4) and **240.6(A)**
7.25 A permits 6 A

Solution: The minimum size overcurrent protection device in the primary side is 3 amps and maximum size overcurrent protection device in the primary side is 6 amps.

Chapter 8
Motors and Compressors

1.	(a)	**430.109(B)**
2.	(d)	**430.109(A)(2)** and **(A)(4)**
3.	(c)	**Article 100** and **430.102(A)** and **(B)**
4.	(a)	**725.48(B)(1)**
5.	(d)	**430.109(C)**
6.	(b)	**440.13** and **440.63**
7.	(a)	**440.14** and **Article 100**
8.	(c)	**440.53**
9.	(a)	**440.62(B)**
10.	(d)	**440.64**
11.	(b)	**430.81(A)**
12.	(a)	**430.83(C)(2)**
13.	(d)	**440.14** and **Article 100**
14.	(c)	**440.62(A)(2)**
15.	(b)	**440.63**
16.	(b)	**440.64**
17.	(b)	**440.22(B)(2), Ex. 2**
18.	(a)	**440.54**
19.	(b)	**440.61** and **250.114(6)**
20.	(c)	**440.63**

21. 430.6(A)(1), Table 430.250, 430.24, and **Table 310.16 – (b)**

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 40 A
40 HP = 52 A
50 HP = 65 A

Step 2: Calculating amperage of multiple motors
430.24
65 A x 125% = 81.25 A
40 A x 100% = 40 A
52 A x 100% = 52 A
Total load = 173.25 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
173.25 A requires 2/0 AWG

Solution: The size THWN copper conductors are required to be 2/0 AWG.

22. 430.52(C)(1), Ex. 2(c), 430.6(A)(1), Table 430.250, and **Table 430.52** - **(d)**

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
50 HP = 130 A

Step 2: Finding maximum percentage size of OCPD
430.52(C)(1), Ex. 2(c)
Maximum size = 300%

Step 3: Calculating maximum size
430.52(C)(1), Ex. 2(c)
130 A x 300% = 390 A

Step 4: Selecting inverse time circuit breaker
Maximum size = 350 A

Solution: The maximum size inverse time circuit breaker is 350 amps.

23. 440.22(A) and **Table 240.4(G) – (b)**

Step 1: Calculating OCPD
440.22(A)
20 A x 225% + 2.5 A = 47.5 A

Step 2: Selecting OCPD
Table 240.4(G) and **240.6(A)**
47.5 A requires 45 A OCPD

Solution: The maximum size overcurrent protection device is 45 amps.

24. 440.32, Footnote to **Table 310.16,** and **Table 240.4(G) – (b)**

Step 1: Calculating FLC
440.32 and **Table 220.3**
20 A x 125% + 2.5 A = 27.5 A

Step 2: Selecting conductors
Footnote to **Table 310.16** and **240.4(D)**
27.5 A requires 10 AWG

Solution: The size conductors are 10 AWG THHN copper.

Chapter 9
Residential Calculations - Single-Family Dwellings

1.	(c)	**220.12** and **Table 220.12**
2.	(c)	**220.52(A)**
3.	(a)	**220.54** and **Table 220.54**
4.	(d)	**220.53**
5.	(b)	**220.60**
6.	(c)	**220.52(B)**
7.	(d)	**220.54** and **Table 220.54**
8.	(b)	**220.54**
9.	(a)	**220.53**
10.	(b)	**220.14(C), 220.50,** and **430.24**

11. Finding general lighting, receptacle, and small appliance plus laundry load – **(b)**

Step 1: General lighting and receptacle load
Table 220.12
3200 sq. ft x 3 VA per sq. ft = 9,600 VA

Step 2: Small-appliance load
220.52(A)
1500 VA x 2 appliance circuits = 3,000 VA

Step 3: Laundry load
220.52(B)
1500 VA x 1 laundry circuit = 1,500 VA

Step 4: Total load

General lighting load	= 9,600 VA
Small-appliance load	= 3,000 VA
Laundry load	= 1,500 VA
Total load	= 14,100 VA

Step 5: Applying demand factor
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 11,100 VA x 35%	= 3,885 VA
Total load	= 6,885 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 6885 VA.

12. Finding load for household electric cooking equipment – **(a)**

Step 1: Calculating the demand load
Table 220.55, Column A
3.5 kW x 2 units x 65% = 4.55 kVA
4.55 kVA x 1000 = 4550 VA

Solution: The total load is 4550 VA.

13. Finding load for household electric range – **(d)**

Step 1: Calculating the percentage
Table 220.55, Note 1
18 kW - 12 kW = 6 kW
6 kW x 5% = 30%

Step 2: Calculating the VA
Table 220.55, Column C
8 kW (1 range) x 130% = 10.4 kVA
10.4 kVA x 1000 = 10,400 VA

Solution: The total load is 10,400 VA.

14. Finding load for household electric range – **(b)**

Step 1: Calculating the percentage
Table 220.55, Note 2
10 kW = 12 kW
12 kW = 12 kW
18 kW = 18 kW
12 kW + 12 kW + 18 kW = 42 kW
Average rating
42 kW ÷ 3 = 14 kW
14 kW - 12 kW = 2 kW
2 kW x 5% (for each kW or major fraction) = 10%

Step 2: Calculating the VA
Table 220.55, Column C
14 kW (3 ranges) x 110% = 15.4 kVA
15.4 kVA x 1000 = 15,400 VA

Solution: The total load is 15,400 VA.

15. Finding the load for household electric cooktop and ovens – **(c)**

Step 1: Calculating the percentage
Table 220.55, Note 4
10 kW + 6 kW + 4 kW = 20 kW
20 kW - 12 kW = 8 kW
8 kW x 5% (for each kW or major fraction) = 40%

Step 2: Calculating the VA
Table 220.55, Column C
8 kW (1 range) x 140% = 11.2 kVA
11.2 kVA x 1000 = 11,200 VA

Solution: The total load is 11,200 VA.

16. Finding load for household electric dryer – **(b)**

Step 1: Calculating the kW
220.54
4.5 kW (nameplate rating) = 5 kW

Step 2: Applying derating factors
Table 220.54
Four or fewer dryers = 100%
5 kW x 100% = 5 kVA
5 kVA x 1000 = 5000 VA

Solution: The total load is 5000 VA.

17. Finding load for household electric dryer – **(d)**

Step 1: Calculating the kW
220.54
5.5 kW (nameplate rating) = 5.5 kW

Step 2: Applying derating factors
Table 220.54
Four or fewer dryers = 100%
5.5 kW x 100% = 5.5 kVA
5.5 kVA x 1000 = 5500 VA

Solution: The total load is 5500 VA.

18. Finding load for fastened-in-place (fixed) appliances – **(a)**

Step 1: Totaling the VA
220.53

Water heater load	= 6,000 VA
Water pump load	= 2,400 VA
Disposal load	= 1,200 VA
Compactor load	= 1,400 VA
Dishwasher load	= 1,400 VA
Microwave load	= 800 VA
Total load	= 13,200 VA

Step 2: Applying demand factors
220.53
13,200 VA x 75% = 9900 VA

Solution: The total load for the phases is 9900 VA.

19. Finding load for fastened-in-place (fixed) appliances –- **(b)**

Step 1: Totaling the VA
220.53

Disposal load	= 1000 VA
Compactor load	= 1400 VA
Dishwasher load	= 1400 VA
Microwave load	= 800 VA
Total load	= 4600 VA

Step 2: Applying demand factors
220.53
4600 VA x 75% = 3450 VA

Solution: The total load for the grounded (neutral) conductor is 3450 VA.

20. Finding load for largest motor – **(c)**

Step 1: Finding FLC
Table 430.248
1 HP = 8 A

Step 2: Calculating FLC
220.14(C), 220.50, 430.22(A), and **430.24**
8 A x 125% = 10 A
10 A x 240 V = 2400 VA

Solution: The total load is 2400 VA.

Chapter 10
Residential Calculations - Multifamily Dwellings

1.	(b)	**220.12** and **Table 220.12**
2.	(a)	**220.52(A)** and **(B)**
3.	(c)	**220.53**
4.	(d)	**220.54**
5.	(a)	**220.60**
6.	(b)	**220.54** and **Table 220.54**
7.	(c)	**220.14(C), 220.50,** and **430.24**
8.	(b)	**220.53**
9.	(d)	**220.55** and **Table 220.50**
10.	(c)	**424.3(B), 210.19(A)(1),** and **440.32**

11. Finding general lighting, receptacle, and small-appliance plus laundry load – **(d)**

Step 1: General lighting and receptacle load
Table 220.12
690 sq. ft per unit x 3 VA x 30 units = 62,100 VA

Step 2: Small-appliance load
220.52(A)
1500 VA x 2 per unit x 30 units = 90,000 VA

Step 3: Laundry load
220.52(B)
1500 VA x 1 per unit x 30 units = 45,000 VA

Step 4: Total load

General lighting and receptacle load	= 62,100 VA
Small-appliance load	= 90,000 VA
Laundry load	= 45,000 VA
Total load	= 197,100 VA

Step 5: Applying demand factor
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remaining 77,100 VA x 25%	= 19,275 VA
Total load	= 63,225 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 63,225 VA.

12. Finding general lighting, receptacle, and small-appliance plus laundry load – **(a)**

Step 1: General lighting and receptacle load
Table 220.12

540 sq. ft per unit x 3 VA x 10 units	= 16,200 VA
680 sq. ft per unit x 3 VA x 10 units	= 20,400 VA
760 sq. ft per unit x 3 VA x 10 units	= 22,800 VA
Total load	= 59,400 VA

Step 2: Small-appliance load
220.52
1500 VA x 2 per unit x 30 units = 90,000 VA

Step 3: Laundry load
220.52
1500 VA x 1 per unit x 30 units = 45,000 VA

Step 4: Total load

General lighting and receptacle load	= 59,400 VA
Small-appliance load	= 90,000 VA
Laundry load	= 45,000 VA
Total load	= 194,400 VA

Step 5: Applying demand factor
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remaining 74,400 VA x 25%	= 18,600 VA
Total load	= 62,550 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 62,550 VA.

13. Finding load for 30 – 12 kW household electric ranges – **(a)**

Step 1: Calculating kVA
Table 220.55, Column C

30 ranges	= 15 kW
1 kW per range	= 30 kW
Total load	= 45 kW

Solution: The total load is 45 kW.

14. Finding load for household electric ovens and cooktops – **(d)**

Step 1: Finding demand factor in percentage
Table 220.55, Column A

3 kW ovens	= 5 units
3 kW cooktops	= 5 units
Total	= 10 units
10 units	= 49%

Step 2: Calculating kVA demand load

Table 220.55, Column A
3 kVA x 10 x 49% = 14.7 kW

Solution: The total demand load is 14.7 kW.

15. Finding load for household electric ovens and cooktops – **(b)**

Step 1: Finding demand factor percentage
Table 220.55, Columns A and **B**

8 kW ovens	= 15 units
3 kW cooktops	= 15 units
Ovens	= 32% (15 units)
Cooktops	= 40% (15 units)

Step 2: Calculating kVA
Table 220.55, Columns A and **B**

Ovens	
8 kW per unit x 15 units x 32%	= 38.4 kW
Cooktops	
3 kW per unit x 15 units x 40%	= 18 kW
Total demand load	= 56.4 kW

Solution: The total demand load is 56.4 kW.

16. Finding the demand load for household electric ranges – **(b)**

Step 1: Finding demand factor percentage
Table 220.55, Note 2
12 kW + 16 kW + 20 kW = 48 kW
48 kW x 8 units = 384 kW
384 kW ÷ 24 = 16 kW
16 kW - 12 kW = 4 kW
4 kW x 5% = 20%

Step 2: Calculating kVA
Table 220.55, Note 2
24 ranges = 39 kW
39 kW x 120% = 46.8 kW

Solution: The total demand load is 46.8 kW.

17. Finding demand load for household electric ranges – **(c)**

Step 1: Finding household electric ranges per phase
220.55
= 10 ÷ 3Ø (phases)
= 4

Step 2: Finding number of ranges
Table 220.55, Column C
= 4 ranges per phase x 2 (phases)
= 8 ranges

Step 3: Finding kW rating
Table 220.55, Column C
8 ranges = 23 kW

Step 4: Finding VA rating
220.55
23 kW x 1000 = 23,000 VA

Step 5: Finding service load
220.55
VA = (23,000 VA ÷ 2) x 3Ø (phases)
VA = 34,500 (equivalent three-phase load)

Solution: The total demand load is 34,500 VA.

18. Finding demand load for fastened-in-place (fixed) appliances – **(d)**

Step 1: Totaling the appliance nameplate VA
220.53

Water heater load	10 x 6000 VA	= 60,000 VA
Disposal load	10 x 1200 VA	= 12,000 VA
Compactor load	10 x 1400 VA	= 14,000 VA
Dishwasher load	10 x 1600 VA	= 16,000 VA
Microwave load	10 x 800 VA	= 8,000 VA
Total load		= 110,000 VA

Step 2: Applying demand factors
220.53
110,000 VA x 75% = 82,500 VA

Solution: The total demand load is 82,500 VA.

19. Finding demand load for fastened-in-place (fixed) appliances – **(a)**

Step 1: Totaling the appliance nameplate VA
220.53

Disposal load	10 x 1200 VA	= 12,000 VA
Compactor load	10 x 1400 VA	= 14,000 VA
Dishwasher load	10 x 1600 VA	= 16,000 VA
Microwave load	10 x 800 VA	= 8,000 VA
Total load		= 50,000 VA

Step 2: Applying demand factors (neutral)
220.53
50,000 VA x 75% = 37,500 VA
37,500 VA ÷ 3 phases = 12,500 VA

Solution: The total demand load for the neutral is 12,500 VA.

20. Finding demand load for household electric dryers – **(b)**

Step 1: Selecting percentage
220.54 and **Table 220.54**
10 dryers = 50%

Step 2: Applying demand factors
Table 220.54
5000 VA x 10 dryers x 50% = 25,000

Solution: The total load is 25,000 VA.

Chapter 11
Commercial Calculations

1.	(a)	**220.12** and **Table 220.12**
2.	(b)	**220.12** and **Table 220.12**
3.	(d)	**220.14(F)**
4.	(a)	**220.60**
5.	(c)	**220.14(C), 220.50,** and **430.24**
6.	(c)	**220.43(A)**
7.	(b)	**220.14(I)**
8.	(c)	**230.42(A)(1)**
9.	(a)	**220.56** and **Table 220.56**
10.	(c)	**220.60, 424.3,** and **440.7**

11. Finding general purpose lighting load – **(b)**

Step 1: Calculating load
Table 220.12
40,000 sq. ft x 3 VA = 120,000 VA
20,000 sq. ft x 1/4 VA = 5,000 VA
Total load = 125,000 VA
125,000 VA x 125% = 156,250 VA

Solution: The general purpose lighting load is 156,250 VA.

12. Finding general purpose lighting load – **(a)**

Step 1: Calculating load
Table 220.12
20,000 sq. ft x 3 VA = 60,000 VA
4000 sq. ft x 1 VA = 4,000 VA
1000 sq. ft x 1 VA = 1,000 VA
Total load = 65,000 VA
65,000 VA x 125% = 81,250 VA

Solution: The general purpose lighting load is 81,250 VA.

13. Finding continuous lighting load – **(d)**

Step 1: Calculating total VA
100 VA x 12 recess = 1,200 VA
150 VA x 14 incandescent = 2,100 VA
180 VA x 20 electric discharge = 3,600 VA
Total load = 6,900 VA

Step 2: Calculating continuous VA
6900 VA x 125% = 8625 VA

Solution: The lighting load for the unlisted occupancy is 8625 VA.

14. Finding show window lighting demand load – **(b)**

Step 1: Calculating load
220.43(A) and **230.42(A)(1)**
120 ft x 200 VA per ft x 125% = 30,000 VA

Solution: The show window lighting demand load is 30,000 VA.

15. Finding sign load – **(c)**

Step 1: Calculating load
220.14(F), 600.5(A), and **230.42(A)(1)**
2400 VA x 125% = 3000 VA

Solution: The sign load is 3000 VA

16. Finding general purpose receptacle demand load – **(a)**

Step 1: Calculating load
220.14(F)
120 receptacles x 180 VA = 21,600 VA

Step 2: Applying demand factors
Table 220.44
First 10,000 VA x 100% = 10,000 VA
Next 11,600 VA x 50% = 5,800 VA
Total load = 15,800 VA

Solution: The general purpose receptacle demand load is 15,800 VA.

17. Finding special-appliance demand load – **(c)**

Step 1: Calculating VA
220.56
8 kW x 20 units = 160 kW

Step 2: Calculating amps
220.5(A)
I = (kW x 1000) ÷ (V x 1.732)
I = (160 kW x 1000) ÷ (208 V x 1.732) (360 V)
I = 444.4 A

Step 3: Applying demand factors
Table 220.56
444.4 A x 65% = 289 A
289 A x 360 V = 104,040 VA

Solution: The special-appliance demand load is 104,040 VA.

18. Finding motor load – **(d)**

Step 1: Finding FLC
40 HP = 104 A
30 HP = 80 A
20 HP = 54 A

Step 2: Calculating total VA
220.5(A)
40 HP motor
240 V x 1.732 (416 V) x 104 A = 43,264 VA
Largest motor load
43,264 VA x 125% = 54,080 VA
30 HP motor
240 V x 1.732 (416 V) x 80 A = 33,280 VA
20 HP motor
240 V x 1.732 (416V) x 54 A = 22,464 VA
Total load = 109,824 VA

Solution: The motor load is 109,824 VA.

19. Finding compressor load – **(a)**

Step 1: Calculating VA
220.5(A)
24.5 A x 4 compressors x 480 V x 1.732 (831 V) = 81,438 VA

Step 2: Calculating total load
230.42(A)(1)
81,438 VA x 100% = 81,438 VA

Solution: The compressor load is 81,438 VA.

20. Finding largest load between heat or A/C – **(c)**

Step 1: Selecting largest load
220.60
Heating load
20 kW x 1000 x 100% = 20,000 VA
A/C load
6.5 kW x 1000 x 100% = 6500 VA

Solution: The 20,000 VA heating unit is the largest load.

Chapter 12

Test Questions

Article 90
Introduction

1.	(d)	**90.2(A)** and **(B)**
2.	(d)	**90.4**
3.	(a)	**90.3**
4.	(d)	**90.3**
5.	(b)	**90.7**

Article 100
Definitions

6.	(c)	**Article 100**
7.	(d)	**Article 100**
8.	(b)	**Article 100**
9.	(a)	**Article 100**
10.	(d)	**Article 100**
11.	(c)	**Article 100**
12.	(b)	**Article 100**
13.	(a)	**Article 100**
14.	(a)	**Article 100**
15.	(c)	**Article 100**
16.	(a)	**Article 100**
17.	(d)	**Article 100**
18.	(b)	**Article 100**
19.	(d)	**Article 100**

Article 110
Requirements for Electrical Installations

20.	(a)	**110.2**
21.	(b)	**110.12**
22.	(d)	**110.14(C)(1)(a)**
23.	(b)	**110.14(C)(1)(b)**
24.	(d)	**110.13(A)**
25.	(b)	**110.14(A)**
26.	(a)	**110.14(C)(1)(a)(2)**
27.	(b)	**110.14(C)(1)(b)(1)** and **(C)(1)(b)(2)**
28.	(b)	**110.26(A)(2)**
29.	(a)	**110.26(A)(1)** and **Table 110.26(A)(1)**
30.	(c)	**110.26(A)(1)** and **Table 110.26(A)(1)**
31.	(b)	**110.26(A)(1)(a)**
32.	(b)	**110.26(C)(2)**
33.	(a)	**110.31**
34.	(b)	**110.26(E)**

Article 200
Use and Identification of Grounded Conductors

35.	(c)	**200.6(A)**
36.	(c)	**200.6(A)**
37.	(a)	**200.6(A)(1)**
38.	(c)	**200.6(B)**
39.	(d)	**200.6(C)**
40.	(c)	**200.6(E)**
41.	(b)	**200.7(C)(2)**
42.	(b)	**200.9**
43.	(c)	**200.10(D)**

Article 210
Branch Circuits

44.	(b)	**210.4(C)**
45.	(a)	**210.4(B)**
46.	(a)	**210.5(B)** and **250.119**
47.	(c)	**210.4(A), FPN**
48.	(c)	**210.11(C)(3)**
49.	(b)	**210.12(B), Ex. 1**
50.	(d)	**Article 100**
51.	(c)	**210.3**
52.	(c)	**210.3**
53.	(b)	**210.3**
54.	(d)	**210.7(B)**
55.	(d)	**210.5(A), 210.5(B), 200.6(A),** and **200.6(B)**
56.	(c)	**310.12(A), 210.5(A),** and **200.6(A)** and **(B)**
57.	(a)	**210.5(B), 250.119,** and **310.12(B)**
58.	(b)	**210.6(A)**
59.	(a)	**210.6(C)(3)**
60.	(a)	**406.3(D)(3)(b)**
61.	(b)	**210.11(C)(2)**
62.	(d)	**210.8(A)(7)**
63.	(c)	**210.19(A)(3), Ex. 1**
64.	(b)	**210.19(A)(4)**
65.	(c)	**210.21(A)**
66.	(a)	**210.23(A)(1)**
67.	(d)	**210.6(D)**
68.	(b)	**210.8(A)(6)** and **406.3(D)(2)**
69.	(d)	**210.23(D)**
70.	(d)	**210.8(A)** and **(B)**
71.	(d)	**210.8(A)(1), (A)(2), (A)(3),** and **(A)(6)**

72. (a) **210.8(A)(5), Ex.**
73. (b) **210.8(A)(3), Ex.**
74. (d) **210.8(A)(3), Ex.**
75. (c) **210.8(B)**
76. (d) **210.23(C)** and **(D)**
77. (a) **210.52(A)(2)(1)**
78. (d) **210.23(A)(2)**
79. (c) **210.50(C)**
80. (a) **210.52(A)(1)**
81. (b) **210.52**
82. (b) **210.52(B)(3)**
83. (d) **210.9, Ex. 2**
84. (c) **240.4(B)(1)**
85. (d) **210.19(A)(2)**
86. (c) **210.19(A)(4), Ex. 1(a)**
87. (d) **210.21(A)**
88. (a) **210.21(B)(1)** and **(B)(3)**
89. (d) **210.52**
90. (a) **210.52(B)(1), 210.11(C)(1),** and **220.52(A)**
91. (c) **210.52(A)(1)**
92. (b) **210.52(A)(2)(2)**
93. (d) **210.52(B)(2)**
94. (c) **210.52(C)(1)**
95. (a) **210.52(C)(3)**
96. (b) **210.11(C)(3)**
97. (d) **210.52(E)**
98. (b) **210.20(A)**
99. (c) **210.23(A), Ex.** and **210.11(C)(1)**
100. (c) **210.52(C)(5), Ex. (1)**
101. (b) **210.52(D)**
102. (a) **210.52(F)**
103. (d) **210.52(H)**
104. (a) **210.62**
105. (c) **210.52(C)(5), Ex.**
106. (d) **210.52(C)(5)**
107. (b) **210.63**
108. (b) **210.70(A)(2)(b)**
109. (a) **210.25**
110. (d) **210.50(A)**
111. (b) **210.52(A)** and **(H)**
112. (c) **210.52(A)(2)(1)**
113. (b) **210.52(A)(2)(2)**
114. (c) **210.52(A)(3)**
115. (c) **210.52**
116. (d) **210.50(B)**
117. (a) **210.52(E)** and **(G)**
118. (c) **210.52(B)(1), Ex. 2**
119. (a) **210.52(B)(1)** and **(B)(2)**
120. (d) **210.52(B)(2), Ex. 2**
121. (a) **210.52(B)(1), Ex. 2**
122. (b) **210.50(C)**
123. (b) **210.52(C)(1)**
124. (b) **210.52(C)**
125. (b) **210.52(C)(3)**
126. (a) **210.52(C)(5), Ex.**
127. (c) **210.52(C)(5)**
128. (c) **210.52(D)** and **210.11(C)(3)**
129. (c) **210.52(E)(1), (E)(2),** and **(E)(3)**
130. (d) **210.11(C)(2)** and **210.52(F)**
131. (c) **210.52(H)**
132. (b) **210.62**
133. (c) **210.63**
134. (d) **210.70(A)(2)(c)**
135. (a) **210.70(A)(1), Ex. 1**
136. (d) **210.70(A), Ex. 2**

137. Sizing branch-circuit overcurrent protection device – (b)

Step 1: Calculating load
210.20(A)
80 A x 125% = 100 A

Step 2: Terminal ratings
110.14(C)(1)(a)(3)
100 A can be terminated at 75°C

Step 3: Sizing conductors
310.10, FPN (2) and **Table 310.16**
100 A requires 3 AWG cu.

Step 4: Sizing OCPD
240.4(B) and **240.6(A)**
3 AWG cu. = 100 A
100 A allows 100 A OCPD

Solution: The size conductors are 3 AWG THWN copper and the size overcurrent protection device is 100 amps.

Article 215
Feeders

138. (a) **215.2(A)(2)**
139. (c) **215.4(A)**
140. (b) **215.10**
141. Sizing feeder conductors – (c)

Step 1: Calculating load
215.2(A)(1)
140 A x 125% = 175 A
50 A x 100% = 50 A
Total load = 225 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
225 A requires 4/0 AWG cu.

Solution: **The size conductors are 4/0 AWG THWN copper.**

Article 220
Branch Circuit, Feeder, and Service Calculations

142. (c) **220.5(B)**
143. (d) **220.12** and **Table 220.12**
144. (c) **220.12** and **Table 220.12**
145. (d) **220.12** and **Table 220.12**
146. (b) **220.14(H)** and **220.44**
147. (b) **220.14(E)**
148. (b) **600.5(A)** and **220.14(FF)**
149. (b) **Table 220.44**
150. (a) **220.50** and **430.24**
151. (d) **220.52(A)** and **210.11(C)(1)**
152. (b) **220.51**
153. (c) **424.3(B)**
154. (b) **220.52(A)**
155. (c) **220.52(B)**
156. (c) **220.53**
157. (d) **220.53**
158. (b) **220.54**
159. (c) **220.54** and **Table 220.54**
160. (a) **220.55** and **Table 220.55**
161. (a) **220.56** and **Table 220.56**

162. General lighting and receptacle loads – (a)

Step 1: General lighting load
Table 220.12
3000 sq. ft x 3 VA = 9,000 VA

Step 2: Small-appliance load
220.52(A)
1500 VA x 2 = 3,000 VA

Step 3: Laundry load
220.52(B)
1500 VA x 1 = 1,500 VA

Step 4: Total load
General-lighting load = 9,000 VA
Small-appliance load = 3,000 VA
Laundry load = 1,500 VA
Total load = 13,500 VA

Step 5: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 10,500 VA x 35% = 3,675 VA
Total load = 6,675 VA

Solution: The general lighting and receptacle loads including the small-appliance and laundry loads is 6675 VA.

163. General-purpose receptacle outlets – (b)

Step 1: Calculating load
220.14(I)
150 receptacles x 180 VA =
27,000 VA

Step 2: Applying demand factors
Table 220.44
First 10,000 VA x 100% = 10,000 VA
Next 17,000 VA x 50% = 8,500 VA
Total load = 18,500 VA

Solution: The receptacle load is 18,500 VA.

164. Fixed-appliance loads – (a)

Step 1: Totaling the VA
220.53
Compactor = 1,000 VA
Disposal = 1,200 VA
Dishwasher = 1,600 VA
Microwave = 1,200 VA
Water pump = 2,600 VA
Total load = 7,600 VA

Step 2: Applying demand factors
220.53
7600 VA x 75% = 5700 VA

Solution: The fixed-appliance load is 5700 VA.

Article 225
Outside Branch Circuits and Feeders

165. (c) **225.6(A)(1)**
166. (b) **225.6(B)**
167. (b) **225.6(B)**
168. (a) **225.14(D)**
169. (c) **225.19(B)**

170. Sizing branch-circuit conductors – (c)

Step 1: Calculating load
210.19(A)(1)
16 A x 125% = 20 A
8 A x 100% = 8 A
Total load = 28 A

Step 2: Selecting conductors
Table 310.16
28 A requires 10 AWG cu.

Solution: The size conductors are 10 AWG THWN copper.

171. Sizing feeder conductors – (d)

Step 1: Calculating load
215.2(A)(1)
150 A x 125% = 187.5 A
20 A x 100% = 20.0 A
Total load = 207.5 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
207.5 A requires 4/0 AWG cu.

Solution: The size conductors are 4/0 AWG THWN copper.

172. Sizing feeder conductors – (b)

Step 1: Calculating load
215.2(A)(1)
120 A x 125% = 150 A
80 A x 100% = 80 A
Total load = 230 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
230 A requires 4/0 AWG cu.

Solution: The size conductors are 4/0 AWG THWN copper.

Article 230
Services

173. (d) **230.2(E)**
174. (c) **230.3**
175. (a) **230.23(B)**
176. (c) **230.9(A)**
177. (b) **230.23(B), Ex.**
178. (c) **230.24(A)**
179. (a) **230.24(B)(2)**
180. (c) **230.24(B)(4)**
181. (d) **230.6(2)**
182. (d) **230.9(A), Ex.**
183. (a) **230.24(A)**
184. (a) **230.24(A), Ex. 3**
185. (d) **230.24(B)(4)**
186. (a) **230.26**
187. (c) **230.79(C)**
188. (b) **230.79(B)**
189. (b) **230.31(B)**
190. (d) **230.32** and **300.5(D)(4)**
191. (a) **230.70(B)**
192. (d) **230.51(A)**
193. (a) **230.72(C)**
194. (c) **230.77**
195. (a) **230.70(A)(1)**
196. (d) **230.71(A)(1)**
197. (d) **230.71(A)**
198. (a) **230.72(C)**
199. (b) **230.79(B)**
200. (d) **230.95**
201. (c) **230.95(A)**

Article 240
Overcurrent protection

202. (a) **Article 100**
203. (b) **240.5(B)(4)**
204. (b) **240.15(B)(2)**
205. (a) **240.24(A)**
206. (c) **240.5(B)(2)**
207. (d) **240.24(C)**
208. (d) **240.50(A)(1)**
209. (a) **240.81**
210. (b) **240.5(B)(2)**
211. (d) **240.21(B)(4)**
212. (a) **210.19(A)(3), Ex. 1**
213. (d) **240.24(B)(2)**
214. (d) **240.40**
215. (b) **240.60(C)**
216. (b) **240.61**

217. Sizing tap conductors – (b)

Step 1: Calculating minimum size tap
240.21(B)(1)(4)
A = 600 A OCPD ÷ 10
A = 60

Step 2: Sizing conductors
Table 310.16
6 AWG THWN cu. = 65 A

Step 3: Verifying size

240.21(B)(1)(4)
65 A is greater than 60 A

Step 4: Calculating OCPD
240.21(B)(1)(1)(b), 240.4(B), and **240.6(A)**
65 A conductors permits 60 A OCPD

Solution: The size overcurrent protection device is 60 amps.

Article 250
Grounding

218. (c) **250.20(A)(1)**
219. (a) **250.34(C)**
220. (b) **250.32(A)**
221. (d) **250.112(M)**
222. (d) **250.106, FPN 2**
223. (c) **250.4(A)(4)** and **(A)(5)**
224. (d) **250.24(A)(1)**
225. (d) **250.30(A)(1)**
226. (d) **250.30(7)**
227. (c) **250.110(1)**
228. (b) **250.140**
229. (c) **250.102(E)**
230. (b) **250.104(D)(1), Ex. 2**
231. (c) **250.52(A)(1)**
232. (d) **250.53(D)(2)**
233. (c) **250.96(A)**
234. (a) **250.102(A)**
235. (d) **250.104(A)(1)**
236. (a) **250.52(A)(1)**
237. (c) **250.66(A)**
238. (d) **250.56**
239. (b) **250.56**
240. (c) **250.120(C)**
241. (c) **250.50**
242. (c) **250.52(A)(1)**
243. (d) **250.53(D)(2), Ex.** and **250.52(A)(1), Ex.**
244. (b) **250.52(A)(3)**
245. (b) **250.56**
246. (b) **250.53(G)**
247. (c) **250.53(G)**
248. (d) **250.56**
249. (b) **250.64(B)**
250. (a) **250.166(B)**
251. (a) **250.166(D)**
252. (c) **250.68(A)**
253. (d) **250.10**
254. (b) **250.166(E)** and **250.52(A)(4)**
255. (d) **250.170**
256. (a) **250.178**
257. (d) **250.118(5)(c)**
258. (c) **250.64(A)**
259. (b) **250.52(A)(4)** and **250.66(B)**
260. (c) **250.66** and **Table 250.66**
261. (b) **250.66(A)**
262. (d) **250.8**

263. Sizing equipment grounding conductor – **(d)**

Step 1: Sizing of OCPD
400 A OCPD requires 3 AWG cu.

Solution: The size equipment grounding conductors is 3 AWG copper.

264. Sizing grounding electrode conductor – (b)

Step 1: Sizing of grounding electrode conductor
3/0 AWG THWN requires 4 AWG cu.

Solution: The size grounding electrode conductor is 4 AWG copper.

Article 300
Wiring Methods

265. (d) **300.3(C)(2)**
266. (c) **300.5(D)(4)**
267. (a) **300.4(A)(2)**
268. (b) **300.7(B)**
269. (d) **300.22(A)**
270. (d) **300.3(C)(1)**
271. (c) **300.4(A)(1**)
272. (b) **300.4(F), Ex. 1**
273. (c) **300.4(G)**
274. (d) **Table 300.5**
275. (d) **300.5(D)(2)**
276. (a) **Table 300.5**
277. (c) **Table 300.5**
278. (c) **Table 300.5**
279. (a) **300.5(D)(1)**
280. (b) **300.5(D)(4)**
281. (b) **Table 300.5**
282. (d) **300.6(D), Ex.**
283. (b) **312.2(A)**
284. (b) **300.14**
285. (a) **Table 300.19(A)**

286. (b) **300.22(B)**
287. (b) **300.22(B)**
288. (c) **300.34**

Article 310
Conductors for general wiring

289. (b) **310.3**
290. (c) **310.4**
291. (a) **310.4**
292. (d) **310.4, Ex. 1**
293. (d) **310.4, Ex. 2**
294. (d) **310.8(C)(2)**
295. (c) **310.12(A)** and **200.6(E)**
296. (c) **310.12(B)** and **250.119(A)**
297. (c) **Article 100**
298. (c) **Table 310.16, correction factors**
299. (b) **310.15(B)(2)(a)**
300. (d) **Table 310.15(B)(2)(a)**
301. (b) **Table 310.15(B)(2)(a)**
302. (d) **310.15(B)(2)(a), Ex. 3**
303. (c) **310.60(C)(2)(b)**
304. (c) **310.15(B)(2)(a), Ex. 4**

305. Finding current-carrying capacity – **(b)**

Step 1: Finding amperage of conductor
Table 310.16
12 AWG THHN cu. = 30 A

Step 2: Finding adjustment factor
Table 310.15(B)(2)(a)
12 conductors requires 50%

Step 3: Finding amperage
Table 310.15(B)(2)(a)
30 A x 50% = 15 A

Solution: The ampacity is limited to 15 amps for each conductor.

306. Finding current-carrying capacity – **(a)**

Step 1: Finding amperage of conductor
Table 310.16
10 AWG THHN cu. = 40 A

Step 2: Finding adjustment factor
8 conductors requires 70%

Step 3: Finding correction factors
Table 310.16
120°F = 82%

Step 4: Finding amperage
Table 310.15(B)(2)(a) and **correction factors**
40 A x 70% x 82% = 22.96 A

Solution: The ampacity is limited to 22.96 amps for each conductor.

Article 312
Cabinets, Cutout Boxes, and Meter Socket Enclosures

307. (b) **312.3**
308. (b) **312.8**
309. (a) **312.11(A)(1)**
310. (a) **312.11(A)(3)**

Article 314
Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings

311. (a) **314.19**
312. (d) **314.28(A)(1)**
313. (c) **314.28(D)**
314. (c) **314.16(B)(1)**
315. (d) **314.16(B)(5)**
316. (b) **314.16(B)(4)**
317. (c) **314.16(B)(3)**
318. (a) **314.16(C)(1)**
319. (a) **314.16(B)(1)**
320. (b) **314.16(B)(5)**
321. (a) **314.16(B)(2)**
322. (b) **314.17(C), Ex.**
323. (a) **314.20**
324. (a) **314.20**
325. (b) **314.21**
326. (d) **314.23(E)**
327. (c) **314.24**

328. Sizing device box – (d)

Step 1: Same size conductors
314.16(B)(1) thru (B)(5)

2 - 12 AWG hots	= 2
2 - 12 AWG neutrals	= 2
1 receptacle	= 2
1 pigtail	= 0
1 bonding jumper	= 0
Total	= 6

Step 2: Selecting box
Table 314.16(A)
6 - 12 AWG requires 3" x 2" x 2-3/4" (70 mm x 50 mm x 70 mm)

Solution: A 3 in. x 2 in. x 2-3/4 in. (70 mm x 50 mm x 70 mm) device box is required.

329. Sizing junction box - angle pull – (b)

Step 1: Finding the multiplier
314.82(A)(2)
multiplier = 6

Step 2: Calculating length
314.28(A)(2)
3" raceway x 6 = 18" (450 mm)

Solution: The minimum length is 18 in. x 18 in. (450 mm x 450 mm)

Article 320
Armored Cable (AC)

330. (a) **320.40**
331. (b) **320.30(C)**
332. (c) **320.23(A)**
333. (d) **320.23(A)**
334. (d) **320.80(A)**

Article 330
Metal-Clad Cable (MC)

335. (d) **330.30(C)**
336. (d) **330.30(B)**
337. (b) **330.17** and **300.4(A)(1)**
338. (a) **330.17** and **300.4(A)(2)**
339. (d) **330.23** and **320.23(A)**

Article 332
Mineral-Insulated, Metal-Sheathed Cable (Type MI)

340. (b) **332.17** and **300.4(A)(1)**
341. (a) **332.17** and **300.4(A)(2)**
342. (c) **332.30(A)**
343. (b) **332.24(2)**

Article 334
Nonmetallic Sheathed Cable (NM, NMC, NMS)

344. (a) **334.15(B)**
345. (c) **334.15(C)**
346. (c) **334.23** and **320.23**
347. (b) **334.17** and **300.4(A)(1)**
348. (a) **334.17** and **300.4(A)(2)**
349. (b) **334.30**
350. (b) **334.30**
351. (d) **334.80**

Article 338 and 340
Service-Entrance (SE, USE) and Underground Feeder Cable (UF)

352. (d) **338.10(B)(4)**
353. (d) **340.12(1)**
354. (a) **340.80**

Article 342
Intermediate Metal Conduit (IMC)

355. (c) **342.20(B)**
356. (c) **342.28**
357. (c) **342.30(B)(1)**
358. (b) **342.30(A)**
359. (d) **342.30(B)(3)**

Article 344
Rigid Metal Conduit (RMC)

360. (a) **344.20(A)**
361. (c) **344.28**
362. (d) **Table 344.30(B)(2)**
363. (d) **344.20(B)**
364. (d) **Table 344.30(B)(2)**
365. (b) **344.30(A)**
366. (b) **344.30(A)**

Article 348
Flexible Metal Conduit (FMC)

367. (d) **348.20(B)**
368. (c) **348.60** and **250.118**
369. (b) **348.30(A)**
370. (b) **348.30(A)**
371. (a) **348.30(A), Ex. 2**

Articles 350 and 356
Liquidtight Flexible Metal Conduit (LFMC) and Liquidtight Flexible Nonmetallic Conduit (LFNC)

372. (a) **350.20(A)**
373. (b) **350.30(A)**
374. (d) **350.60** and **250.118(7)(c)**
375. (a) **356.30(1)**

376. (c) **356.30(3)**

Article 352
Rigid Polyvinyl Chloride Conduit: Type PVC

377. (b) **352.12(B)**
378. (a) **352.30(A)**
379. (b) **Table 352.30**
380. (a) **352.44**

Article 358
Electrical Metallic Tubing (EMT)

381. (b) **358.20(B)**
382. (c) **358.26**
383. (d) **358.30(A)**
384. (a) **358.30(A)**
385. (c) **358.30(A), Ex. 1**

Article 362
Electrical Nonmetallic Tubing (ENT)

386. (d) **362.2**
387. (a) **362.10(2)**
388. (b) **362.20(B)**
389. (c) **362.26**
390. (c) **362.30(A)**

Article 366
Auxiliary Gutters

391. (c) **366.12(2)**
392. (a) **366.30(B)**
393. (b) **366.22(A)** and **366.23(A)**
394. (b) **366.22(B)**

Article 368
Busways

395. (b) **368.12(E)**
396. (b) **368.30**
397. (c) **368.10(C)(2)(a)**
398. (d) **368.56(B)(2)**
399. (c) **368.17(D), Ex.**

Articles 384 and 386
Surface Metal Raceways and Strut-type Channel Raceway

400. (c) **386.22(1) thru (3)**
401. (c) **386.56**
402. (a) **386.60**
403. (a) **384.30(A)**
404. (d) **384.30(B)**

Article 392
Cable Trays

405. (b) **392.6(A)**
406. (a) **392.6(C)**
407. (d) **392.7(B)**
408. (c) **392.3(B)(1)(a)**
409. (b) **392.2**
410. (d) **392.6(J)**
411. (c) **392.13(B)(1)**
412. (b) **392.13(B)(1)**

Article 398
Open Wiring on Insulators

413. (b) **398.30(A)(1)**
414. (b) **398.30(A)(2)**
415. (c) **398.30(A)(3)**
416. (b) **398.19**
417. (c) **398.15(C)**

Article 394
Concealed Knob-and-Tube Wiring

418. (c) **394.19(A)**
419. (a) **394.19(A)**
420. (b) **394.17**
421. (b) **394.23(A)**

Article 400
Flexible Cords and Cables

422. (c) **400.5(A)** and **Table 400.5(A)**
423. (c) **400.7** and **400.8**
424. (a) **400.22(F)**
425. (d) **400.31(A)**

Article 402
Fixture Wires

426. (b) **402.5** and **Table 402.5**
427. (c) **402.5** and **Table 402.5**
428. (a) **402.6**

Article 404
Switches

429. (d) **404.8(A)**
430. (d) **404.8(B)**
431. (d) **404.13(A)**
432. (c) **404.14(A)(3)**
433. (a) **404.14(B)(2)**

Article 408
Switchboard and Panelboards

434. (d) **408.18(B)** and **110.26(F)(1)(a)**
435. (a) **408.17**
436. (c) **408.3(E)**
437. (c) **408.54**
438. (d) **408.36(A)**
439. (a) **408.54** and **110.26(F)(1)(a)**
440. (c) **408.18(A)**
441. (b) **408.5**
442. (c) **408.5** and **Table 408.5**
443. (c) **408.55, Ex. 1**
444. (a) **408.55, Ex. 3**
445. (c) **408.36(C)**
446. (b) **408.40**

Article 410
Luminaires, Lampholders, and Lamps

447. (b) **410.16(D)(4)**
448. (c) **410.30(A)**
449. (b) **410.64**
450. (d) **410.116(A)**
451. (a) **410.10(D)**
452. (d) **410.16(D)(3)**
453. (b) **410.30(B)(1)**
454. (c) **410.10(A)**
455. (b) **410.10(D)**
456. (c) **410.30(B)(1), Ex. 2**
457. (c) **410.16(D)(1)**
458. (d) **410.36(A)** and **314.27(B)**
459. (d) **410.24(A)**
460. (c) **410.116(B)**
461. (c) **410.135**
462. (c) **410.136(B)**

Article 411
Lighting Systems Operating at 30 Volts or Less

463. (b) **411.4(B)**
464. (c) **411.5(C)**
465. (b) **411.6**

Article 422
Appliances

466. (b) **422.16(B)(1)**
467. (b) **422.16(B)(2)**
468. (d) **422.48(A)**
469. (a) **422.16(B)(3)**
470. (a) **422.18(A)**
471. (c) **422.31(A)**
472. (a) **422.32**
473. (b) **422.11(F)(1)**

Article 424
Fixed Electric Space Heating Equipment

474. (b) **424.36**
475. (c) **424.39**

Article 426
Fixed Outdoor Electric Deicing and Snow-Melting Equipment

476. (c) **426.4**
477. (b) **426.20(C)(2)**
478. (a) **426.50** and **51**

Article 430
Motors, Motor Circuits, and Controllers

479. (d) **430.6(A)(1)** and **Table 430.250**
480. (c) **430.22(E)** and **Table 430.22(E)**
481. (a) **430.23(A)**
482. (c) **Table 430.52** and **430.52(C)(1), Ex. 2**
483. (d) **430.22(A)**
484. (a) **430.22(C)**
485. (b) **430.128**
486. (c) **430.24**

487. (c)	**430.52(C)(1)** and **Table 430.52**
488. (b)	**430.6(A)(1)**
489. (a)	**430.6(A)(2)**
490. (b)	**430.6(B)**
491. (b)	**430.10(B)** and **Table 430.10(B)**
492. (d)	**430.35(B), Ex.**
493. (b)	**430.33**
494. (a)	**430.32(B)(1)**
495. (a)	**430.31**
496. (c)	**430.7(B)**
497. (d)	**430.32(A)(1)**
498. (b)	**430.52(C)(1), Ex. 2(b)**
499. (a)	**430.62(A)**
500. (c)	**430.52(C)(1), Ex. 2(a)**
501. (b)	**430.52(C)(1), Ex. 2(c)**
502. (c)	**Table 430.7(B)**
503. (c)	**430.6(A)(1)** and **430.22(A)**
504. (a)	**430.52(B)**
505. (d)	**430.51**
506. (c)	**430.81(C)**
507. (b)	**110.20** and **Table 110.20**
508. (d)	**Article 100** and **430.102(B)**
509. (a)	**430.109(B)**
510. (c)	**430.109(A)(1)**
511. (b)	**430.110(A)**
512. (b)	**430.81(B)**
513. (a)	**430.83(A)(2)**
514. (c)	**430.109(C)(1)**
515. (d)	**430.53(A)**
516. (c)	**430.32(A)(1)**
517. (b)	**430.83(A)(1)**
518. (a)	**430.83(D)**
519. (c)	**430.122(A)**
520. (d)	**430.52(C)(3), Ex. 1**
521. (c)	**Table 430.52** and **Text**
522. (b)	**430.32(A)(1)**
523. (b)	**430.32(A)(1)**
524. (d)	**430.32(C)**
525. (d)	**430.32(C)**
526. (c)	**430.83(C)(2)**
527. (b)	**430.233**

528. Sizing inverse-time circuit breaker – **(b)**

Step 1: Finding FLA
430.6(A)(1) and **Table 430.250**
30 HP = 40 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(c) and **Table 430.52**
Maximum size = 400%

Step 3: Calculating minimum size
430.52(C)(1), Ex. 2(c)
Max. size = 40 A x 400%
Max. size = 160 A

Step 4: Selecting inverse time circuit breaker
Max. size = 150 A

Solution: **The maximum size inverse time circuit breaker is 150 amps.**

529. Sizing overcurrent protection device for feeder – **(b)**

Step 1: Finding FLC of motors
430.6(A)(1) and **Table 430.250**
20 HP = 27 A
30 HP = 40 A
40 HP = 52 A (largest)

Step 2: Calculating feeder OCPD
430.52(A), Table 430.52, and **430.62(A)**

52 A x 250%	= 130 A
	= 150 A OCPD
	= 40 A
	= 27 A
Total load	= 217 A

Step 3: Selecting OCPD
430.62(A), 240.4(G, and **240.6(A)**
217 A requires 200 A OCPD

Solution: **The size overcurrent protection device is 200 amps.**

530. Sizing THWN copper conductors – **(d)**

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
20 HP = 27 A
30 HP = 40 A
40 HP = 52 A

Step 2: Sizing conductors
430.24

52 A x 125%	= 65 A
40 A x 100%	= 40 A
27 A x 100%	= 27 A
Total load	= 132 A

Step 3: Selecting conductors
310.10, FPN (2) and **Table 310.16**
132 A requires 1/0 AWG THWN cu.

Solution: **The size conductors are 1/0 AWG THWN copper.**

531. Sizing minimum overload protection – **(c)**

Step 1: Finding FLA

430.6(A)(2)
Nameplate = 67 A

Step 2: Finding percentage
430.32(A)(1)
Service factor = 125%
Temperature rise = 125%

Step 3: Calculating FLA
430.32(A)(1)
67 A x 125% = 83.75 A

Step 4: Selecting time-delay fuses
430.32(A)(1) and **240.6(A)**
83.75 A requires 80 A

Solution: **The minimum size overload protection is 80 amps.**

Article 440
Air-Conditioning and Refrigerating Equipment

532. (d) **440.4(A)**
533. (b) **440.12(A)(2)** and **430.109**
534. (d) **440.13**
535. (a) **440.7, 430.24,** and **440.33**
536. (c) **440.12(A)(1)**
537. (d) **Article 100** and **440.14**
538. (b) **440.22(B)(1)** and **440.22(A)**
539. (c) **440.33**
540. (d) **440.52(A)(1)**
541. (a) **440.55**
542. (c) **440.62(A)(2)**
543. (d) **440.63**
544. (a) **440.64**
545. (d) **440.22(A)**
546. (b) **440.22(B)(2), Ex. 2**
547. (d) **440.61** and **250.114(2)**
548. (c) **440.63**

549. Sizing THWN copper conductors – **(b)**

Step 1: Finding FLC
440.32

24 A x 125%	= 30.0 A
1.5 A x 100%	= 1.5 A
Total load	= 31.5 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
31.5 A requires 10 AWG THWN cu.

Solution: **The size THWN copper conductors are 10 AWG.**

Article 450
Transformers and Transformer Vaults

550. (a) **450.7**
551. (d) **450.10**
552. (c) **450.43(A)**
553. (d) **450.46**
554. (b) **450.45**
555. (a) **450.13(B)**
556. (b) **450.3(A)** and **Table 450.3(A)**
557. (c) **450.3(A)** and **Table 450.3(A)**
558. (a) **450.3(B)** and **Table 450.3(B)**
559. (c) **110.27(A)(4)** and **450.8(C)**
560. (d) **450.21(C)**
561. (a) **450.42**
562. (d) **450.43(B)**
563. (b) **450.3, FPN 1** and **240.21(C)(3)**
564. (d) **450.3(A)** and **Table 450.3(A)**
565. (b) **450.21(A)**
566. (a) **450.25**
567. (b) **450.42**

Article 490,
Equipment, Over 600 Volts, Nominal

568. (a) **490.38**
569. (d) **490.41(A), Ex.**
570. (b) **490.21(D)(7)**
571. (d) **490.41(A)**

Article 500
Hazardous (Classified) Locations

572. (d) **500.7(A)**
573. (d) **500.7(E)**
574. (b) **500.7(F)**
575. (b) **500.5(B)(1)** and **(B)(2)**
576. (d) **500.5(C)(1)**
577. (a) **500.6(A)(1)**
578. (d) **500.6(A)(3)** and **FPN**
579. (b) **500.6(B)(1)**
580. (c) **500.8(B)(2)**
581. (c) **500.5(D)**

Article 501
Class I Locations

582. (b) **501.10(A)(2), 501.10(B)(2)(5),** and **501.140**

583. (a) **501.15, FPN 1**
584. (c) **501.25**
585. (b) **500.8(E)**
586. (c) **501.10(A)(1), Ex.**
587. (b) **501.130(A)(3)**
588. (c) **501.15(A)(1)**
589. (b) **501.15(C)(6)**

Article 511
Commercial Garages, Repair, and Storage

590. (d) **511.3(C)(1)(a)**
591. (a) **511.3(C)(2)(a)**
592. (c) **511.3(D)(1)(b)**
593. (b) **511.7(B)(1)(a)**

Article 513
Aircraft Hangers

594. (c) **513.10(C)(1)** and **513.9**
595. (a) **513.7(A)**
596. (c) **513.3(B)**
597. (b) **513.3(C)(1)**
598. (b) **513.10(D)(1)**

Article 514
Gasoline Dispensing and Service Stations

599. (b) **514.2**
600. (d) **514.16**
601. (c) **Table 514.3(B)(1)**
602. (b) **514.8, Ex. 2**
603. (d) **514.11(C)**

Article 515
Bulk Storage Plants

604. (c) **Table 515.3**
605. (c) **Table 515.3**
606. (b) **515.8(A)**

Article 517
Health Care Facilities

607. (a) **517.13(A)**
608. (c) **517.18(A)**
609. (d) **517.19(A)**
610. (b) **517.21**
611. (d) **517.30(D)**
612. (d) **517.13(B), Ex. 2**
613. (b) **517.14**
614. (b) **517.18(B)**
615. (c) **517.19(B)(1)**
616. (b) **517.31**

Article 525
Carnivals, Circuses, Fairs, and Similar Events

617. (b) **525.11**
618. (a) **525.21(A)**
619. (d) **525.22(A)**
620. (d) **525.23**
621. (b) **525.5(B)(1)**
622. (b) **525.5(B)(2)**
623. (d) **525.20(B)**
624. (b) **525.22(A)**
625. (a) **525.21(A)**

Article 550
Mobile Homes, Manufactured Homes, and Mobile Home Parks

626. (c) **550.10(A)**
627. (b) **550.13(B)**
628. (c) **550.13(D)**
629. (b) **550.18(A)(2)**
630. (d) **550.32(A)**

Article 590
Temporary Wiring

631. (c) **590.3(B)**
632. (d) **590.3(C)**
633. (a) **590.4(B), (C),** and **(D)**
634. (a) **590.4(G)**
635. (b) **590.6(A)**

Article 600
Electric Signs and Outline Lighting

636. (b) **600.5(A)**

637. (a) **600.6(A)(1)**
638. (a) **600.6(A)(2)(1)**
639. (c) **600.10(C)(2)**
640. (c) **600.5(B)(2)**
641. (b) **600.5(A)** and **220.14(F)**
642. (c) **600.7(B)(4)**
643. (c) **600.9(A)**
644. (b) **600.21(E)**

645. Sizing load in VA for sign – **(d)**

Step 1: Calculating load
210.19(A)(1)
2400 VA x 125% = 3000 VA

Solution: **The sign load is 3000 VA.**

Article 610
Cranes and Hoists

646. (c) **610.21(C)**
647. (c) **610.33**
648. (b) **610.57**

Article 620
Elevators, Dumbwaiters, Escalators, Moving Walks, Platform lifts, and Stairway Chairlifts

649. (b) **620.12(A)(1)**
650. (a) **620.21(A)(3)(a)**
651. (c) **620.32**
652. (c) **620.44**
653. (d) **620.85**

Article 625
Electric Vehicle Charging System Equipment

654. (c) **625.22**
655. (d) **625.23**
656. (d) **625.29(B)**
657. (c) **625.30(B)**

Article 630
Electric Welders

658. (c) **Table 630.11(A)**
659. (b) **630.12(A)**
660. (b) **Table 630.31(A)(2)**
661. (c) **630.32(A)**
662. (d) **630.42(A)**

663. Sizing overcurrent protection device for motor-generator arc welder – **(a)**

Step 1: Finding FLC
630.12(A) and **630.12(B)**
Welder = 54 A

Step 2: Finding multiplier
630.12(A)
Multiplier = 200%

Step 3: Calculating amperage
630.12(A) and **630.12(B)**
54 A x 200% = 108 A

Step 4: Selecting OCPD for disconnect
240.4(G), 240.6(A), and **630.12(A)**
108 A requires 100 A

Solution: **The size overcurrent protection device required is 100 amps.**

Article 680
Swimming Pools, Fountains, and Similar Installations

664. (b) **680.22(A)(3)**
665. (d) **680.22(A)(3)**
666. (b) **680.22(A)(3)**
667. (d) **680.22(A)(4)**
668. (b) **680.22(C)(1)**
669. (d) **680.22(C)(1)**
670. (b) **680.22(B)(2)**
671. (c) **680.22(D)**
672. (a) **680.10**
673. (b) **680.12**
674. (d) **680.23(A)(5)**
675. (c) **680.23(B)(2(b)**
676. (c) **680.24(A)(2)(a)**
677. (a) **680.23(B)(2)(b)**
678. (c) **680.26(B)(2)**
679. (a) **680.23(F)(2)**
680. (a) **680.43(A)**
681. (c) **680.43(A)(2)**
682. (a) **680.43(C)**
683. (c) **680.71**

Article 700
Emergency Systems

684. (a) **700.8(A)**

685. (a) **700.9(D)(1)**

686. (b) **700.12(A)**

Article 725
Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits

687. (a) **725.31(A)**

688. (d) **725.41(B)**

689. (c) **725.43**

690. (a) **725.48(B)(1)**

691. (b) **725.136(J)**

Article 760
Fire Alarm Systems

692. (b) **760.43**

693. (d) **760.53**

694. (d) **760.136(A)**

695. (b) **760.136(G)**

Article 800
Communications Circuits

696. (a) **800.44(B)**

697. (b) **800.50(B)**

698. (a) **800.53**

699. (c) **800.40(D)**

700. (a) 800.106(B)

Chapter 13
Test Problems

Article 110
Requirements for Electrical Installations

1. Sizing overcurrent protection devices at 60°C

Step 1: Finding ampacity
110.14(C)(1)(A)
60°C terminals per **Table 310.16** permits 2 AWG THWN cu. to have an ampacity of 95 amps

Solution: A 2 AWG THWN copper conductor can be loaded to 95 amps with 60°C terminals.

2. Sizing overcurrent protection devices at 75°C

Step 1: Finding ampacity
110.14(C)(1)(b)
75°C terminals per **Table 310.16** permits 4/0 AWG THWN cu. to have an ampacity of 230 amps

Solution: A 4/0 AWG THWN copper conductor can be loaded to 230 amps with 75°C terminals

Article 210
Branch Circuits

3. Voltage drop

Step 1: Selecting percentage
210.19(A)(1), FPN 4
Branch circuit = 3%

Step 2: Calculating VD
210.19(A)(1), FPN 4 and **Table 8, Ch. 9**
VD = (2 x R x L x I) ÷ 1000
VD = (2 x .245 x 200’ x 100 A) ÷ 1000
VD = 9800 ÷ 1000
VD = 9.8 V

Step 3: Calculating allowable VD
VD = supply V x 3%
VD = 240 V x 3%
VD = 7.2 V

Step 4: Calculating percentage
210.19(A)(1), FPN 4
% = VD ÷ V
% = 9.8 V ÷ 240 V
% = .0408 or 4.08

Solution: The voltage drop rating of 9.8 volts is greater than 7.2 volts and a larger conductor shall be used to reduce 4.08 percent to 3 percent or less.

Using a larger conductor
(1 AWG cu.)

Step 1: Selecting percentage
210.19(A)(1), FPN 4
Branch circuit = 3%

Step 2: Calculating VD
210.19(A)(1), FPN 4 and **Table 8, Ch. 9**
VD = (2 x R x L x I) ÷ 1000
VD = (2 x .154 x 200’ x 100 A) ÷ 1000
VD = 6160 ÷ 1000
VD = 6.16

Step 3: Checking percentage
210.19(A)(1), FPN 4
% = 6.16 V ÷ 240 V
% = .0256 or 2.56

Solution: The 1 AWG conductor is large enough to reduce the voltage drop to 3 percent or less.

4. Voltage drop

Step 1: Selecting percentage
210.19(A)(1), FPN 4
Branch circuit = 3%

Step 2: Calculating VD
210.19(A)(1), FPN 4 and **Table 8, Ch. 9**
VD = (2 x R x L x I) ÷ 1000
VD = (2 x .194 x 200' x 100 A) ÷ 1000
VD = 7760 ÷ 1000
VD = 7.76 x .866 = 6.72

Step 3: Calculating allowable VD
VD = supply V x 3%
VD = 240 V x 3%
VD = 7.2 V

Step 4: Calculating percentage
210.19(A)(1), FPN 4
% = VD ÷ V
% = 6.72 V ÷ 240 V
% = .0280 or 2.80

Solution: The 2 AWG conductor is large enough to reduce the voltage drop to 3 percent or less.

5. Branch-circuit lighting load

Step 1: Calculating OCPD
210.20(A)

12 A x 125%	= 15 A
5 A x 100%	= 5 A
Total load	= 20 A

Step 2: Selecting OCPD
Table 310.16, 240.4(D), and **240.4(B)**
20 A requires 20 A OCPD

Step 3: Calculating conductors
210.19(A)(1)

12 A x 125%	= 15 A
5 A x 100%	= 5 A
Total load	= 20 A

Step 4: Selecting conductors
Table 310.16, 240.4(D), and **240.4(B)**
20 A requires 12 AWG THWN

Solution: A 20 amp overcurrent protection device and 12 AWG THWN copper conductors are required.

6. Branch-circuit lighting load

Step 1: Calculating OCPD
210.20(A)

8 A x 125%	= 10 A
10 A x 100%	= 10 A
Total load	= 20 A

Step 2: Selecting OCPD
Table 310.16, 240.4(D), and **240.4(B)**
20 A requires 20 A OCPD

Step 3: Calculating conductors
210.19(A)(1)

8 A x 125%	= 10 A
10 A x 100%	= 10 A
Total load	= 20 A

Step 4: Selecting conductors
Table 310.16, 240.4(D), and **240.4(B)**
20 A requires 12 AWG THWN

Solution: A 20 amp overcurrent protection device and 12 AWG THWN copper conductors are required.

7. Added air-conditioner window unit

Step 1: Finding amps of branch circuit
210.23(A)(2)
A = 1/2 of 20 A OCPD
A = 10 A

Step 2: Calculating amps for air-conditioner unit
210.23(A)(2), 440.62(B) and **(C),** and **440.32**
8 A x 125% = 10 A

Step 3: Verifying permissive amps
210.23(A)(1), 440.62(B) and **(C),** and **210.3**
20 A OCPD x 80% = 16 A

Solution: Yes, the air-conditioner window unit rated at 8 amps or 10 amps for sizing elements can be connected to the 20 amp branch circuit.

Article 215
Feeders

8. Voltage drop

Step 1: Selecting percentage
215.2(A), FPN 2
Feeder = 3%

Step 2: Calculating allowable VD
VD = supply V x 3%
VD = 240 V x 3%
VD = 7.2 V

Step 3: Calculating CM
215.2(A), FPN 2 and **Table 8, Ch. 9**
CM = (2 x K x L x I) ÷ VD
CM = (2 x 12 x 100' x 84 A) ÷ 7.2 VD
CM = 201,600 ÷ 7.2
CM = 28,000

Solution: The CM rating of 28,000 requires 4 AWG THWN copper conductors.

9. Feeder conductors

Step 1: Calculating load
215.2(A)(1)

150 A x 125%	= 187.5 A
40 A x 100%	= 40 A
Total load	= 227.5 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
227.5 A requires 4/0 AWG cu.

Solution: The size conductors are 4/0 AWG THWN copper.

10. Feeder conductors

Step 1: Calculating load
215.2(A)(1)

172 A x 125%	= 215 A
80 A x 100%	= 80 A
Total load	= 295 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
295 A requires 350 KCMIL cu.

Solution: The size conductors are 350 KCMIL THWN copper.

11. Transformer secondary conductors

Step 1: Finding amps of loads
215.2(A)(1)

50 A x 125%	= 62.5 A
20 A x 100%	= 20 A
Total load	= 82.5 A

Step 2: Sizing conductors
310.10, FPN (2) and **Table 310.16**
82.5 A requires 4 AWG cu.

Solution: The size of the secondary conductors are 4 AWG THWN copper.

12. Transformer secondary conductors

Step 1: Finding amps of loads
215.2(A)(1)

68 A x 125%	= 85 A
38 A x 100%	= 38 A
Total load	= 123 A

Step 2: Sizing conductors
310.10, FPN (2) and **Table 310.16**
123 A requires 1 AWG cu.

Solution: The size of the secondary conductors are 1 AWG THWN copper.

13. Sizing conductors for the secondary side of a transformer

Step 1: Calculating load
215.2(A)(1) and **Table 450.3(B)**
194 A x 125% = 242.5 A

Step 2: Sizing conductors
310.10, FPN and **Table 310.16**
242.5 A requires 250 KCMIL cu.

Solution: The size conductors are 250 KCMIL THWN copper.

14. Sizing conductors for the secondary side of a transformer

Step 1: Calculating load
215.2(A)(1) and **Table 450.3(B)**
212 A x 125% = 265 A

Step 2: Sizing conductors
310.10, FPN (2) and **Table 310.16**
265 A requires 300 KCMIL cu.

Solution: The size conductors are 300 KCMIL THWN copper.

Article 220
Branch Circuit, Feeder, and Service Calculations

15. Finding general lighting, receptacle, and small-appliance plus laundry load

Step 1: General lighting and receptacle load
Table 220.12

3000 sq. ft x 3 VA	= 9,000 VA

Step 2: Small-appliance load
220.52(A)

1500 VA x 2	= 3,000 VA

Step 3: Laundry load
220.52(B)

1500 VA x 1	= 1,500 VA

Step 4: Total load

General lighting and receptacle load	= 9,000 VA
Small-appliance load	= 3,000 VA
Laundry load	= 1,500 VA
Total load	= 13,500 VA

Step 5: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 10,500 VA x 35%	= 3,675 VA
Total load	= 6,675 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 6675 VA.

16. Finding general lighting, receptacle, and small-appliance plus laundry load

Step 1: General lighting and receptacle load
Table 220.12

3200 sq. ft x 3 VA	= 9,600 VA

Step 2: Small-appliance load
220.52(A)

1500 VA x 2	= 3,000 VA

Step 3: Laundry load
220.52(B)

1500 VA x 1	= 1,500 VA

Step 4: Total load

General lighting and receptacle load	= 9,600 VA
Small-appliance load	= 3,000 VA
Laundry load	= 1,500 VA
Total load	= 14,100 VA

Step 5: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 11,100 VA x 35%	= 3,885 VA
Total load	= 6,885 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 6885 VA.

17. Finding general lighting, receptacle, and small-appliance plus laundry load

Step 1: General lighting and receptacle load
Table 220.12

980 sq. ft x 3 VA x 20 units	= 58,800 VA

Step 2: Small-appliance load
220.52(A)

1500 VA x 2 per unit x 20 units	= 60,000 VA

Step 3: Laundry load
220.52(B)

1500 VA x 1 per unit x 20 units	= 30,000 VA

Step 4: Total load

General lighting and receptacle load	= 58,800 VA
Small-appliance load	= 60,000 VA
Laundry load	= 30,000 VA
Total load	= 148,800 VA

Step 5: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remainder 28,800 VA x 25%	= 7,200 VA
Total load	= 51,150 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 51,150 VA.

18. Finding general lighting, receptacle, and small-appliance plus laundry load

Step 1: General lighting and receptacle load
Table 220.12

1280 sq. ft x 3 VA x 15 units	= 57,600 VA

Step 2: Small-appliance load
220.52(A)

1500 VA x 2 per unit x 15 units	= 45,000 VA

Step 3: Laundry load
220.52(B)

1500 VA x 1 per unit x 15 units	= 22,500 VA

Step 4: Total load

General lighting and receptacle load	= 57,600 VA
Small-appliance load	= 45,000 VA
Laundry load	= 22,500 VA
Total load	= 125,100 VA

Step 5: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remainder 5100 VA x 25%	= 1,275 VA
Total load	= 45,225 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 45,225 VA.

19. Finding general lighting, receptacle, and small-appliance plus laundry load

Step 1: General lighting and receptacle load
Table 220.12

875 sq. ft x 3 VA x 10 units	= 26,250 VA
920 sq. ft x 3 VA x 10 units	= 27,600 VA
1050 sq. ft x 3 VA x 10 units	= 31,500 VA
Total load	= 85,350 VA

Step 2: Small-appliance load
220.52(A)

1500 VA x 2 per unit x 30 units	= 90,000 VA

Step 3: Laundry load
220.52(B)

1500 VA x 1 per unit x 30 units	= 45,000 VA

Step 4: Total load

General lighting load	= 85,350 VA
Small-appliance load	= 90,000 VA
Laundry load	= 45,000 VA
Total load	= 220,350 VA

Step 5: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remainder 100,350 VA x 25%	= 25,088 VA
Total load	= 69,038 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 69,038 VA.

20. Finding general lighting, receptacle, and small appliance plus laundry load

Step 1: General lighting and receptacle load
Table 220.12

1000 sq. ft x 3 VA x 5 units	= 15,000 VA
1050 sq. ft x 3 VA x 5 units	= 15,750 VA
1200 sq. ft x 3 VA x 5 units	= 18,000 VA
1280 sq. ft x 3 VA x 5 units	= 19,200 VA
Total load	= 67,950 VA

Step 2: Small-appliance load
220.52(A)

1500 VA x 2 per unit x 20 units	= 60,000 VA

Step 3: Laundry load
220.52(B)

1500 VA x 1 per unit x 20 units	= 30,000 VA

Step 4: Total load

General lighting load	= 67,950 VA
Small-appliance load	= 60,000 VA
Laundry load	= 30,000 VA
Total load	= 157,950 VA

Step 5: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA

Next 117,000 VA x 35% = 40,950 VA
Remainder 37,950 VA x 25% = 9,488 VA
Total load = 53,438 VA

Solution: The general lighting, receptacle, and small-appliance plus laundry load is 53,438 VA.

21. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(2)**
7000 sq. ft x 3.5 VA x 125% = 30,625 VA

Solution: The general lighting and receptacle load is 30,625 VA.

22. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(2)**
8400 sq. ft x 1 VA x 125% = 10,500 VA

Solution: The general lighting and receptacle load is 10,500 VA.

23. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(2)**
6800 sq. ft x 3.5 VA x 125% = 29,750 VA

Solution: The general lighting and receptacle load is 29,750 VA.

24. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(2)**
4800 sq. ft x 2 VA x 125% = 12,000 VA

Solution: The general lighting and receptacle load is 12,000 VA.

25. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(2)**
2400 sq. ft x 3 VA x 125% = 9000 VA

Solution: The general lighting and receptacle load is 9000 VA.

26. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(1)**
52,000 sq. ft x 2 VA x 100% = 104,000 VA

Step 2: Applying demand factors
Table 220.42
First 50,000 VA x 40% = 20,000 VA
Next 54,000 VA x 20% = 10,800 VA
Total load = 30,800 VA

Solution: The general lighting and receptacle load is 30,800 VA.

27. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(1)**
420 sq. ft x 2 VA x 50 units = 42,000 VA

Step 2: Applying demand factors
Table 220.42
First 20,000 VA x 50% = 10,000 VA
Next 22,000 VA x 40% = 8,800 VA
Total load = 18,800 VA

Solution: The general lighting and receptacle load is 18,800 VA.

28. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.43(A)(2)**
40,000 sq. ft x 3 VA = 120,000 VA
20,000 sq. ft x 1/4 VA = 5,000 VA
load = 125,000 VA
Total load. = 125,000 VA x 125% = 156,250 VA

Solution: The general lighting and receptacle load is 156,250 VA.

29. Finding general lighting and receptacle load

Step 1: Calculating load
Table 220.12 and **230.42(A)(2)**
20,000 sq. ft x 3 VA = 60,000 VA
4,000 sq. ft x 1 VA = 4,000 VA
1,000 sq. ft x 1 VA = 1,000 VA
Load = 65,000 VA
Total load. = 65,000 VA x 125% = 81,250 VA

Solution: The general lighting and receptacle load 81,250 VA.

30. Finding continuous lighting load

Step 1: Calculating load in amps
220.18(B)
50 units x 1.5 A = 75 A

Step 2: Calculating continuous load
230.42(A)(2)
75 A x 125% = 93.75 A

Step 3: Calculating VA
220.5(A)
93.75 A x 120 V = 11,250 VA

Solution: The lighting load for the unlisted occupancy is 11,250 VA.

31. Finding continuous lighting load

Step 1: Calculating total VA
120 VA x 10 units = 1,200 VA
150 VA x 12 units = 1,800 VA
180 VA x 22 units = 3,960 VA

Total load = 6,960 VA

Step 2: Calculating continuous VA
6960 VA x 125% = 8700 VA

Solution: The lighting load for the unlisted occupancy is 8700 VA.

32. Finding show window lighting load

Step 1: Calculating load
220.14(G), 220.43(A), and **230.42(A)(1)**
140 ft x 200 VA x 100% = 28,000 VA

Solution: The show window lighting load is 28,000 VA.

33. Finding show window lighting load

Step 1: Calculating load
220.14(G), 220.43(A), and **230.42(A)(2)**
140 ft x 200 VA x 125% = 35,000 VA

Solution: The show window lighting load is 35,000 VA.

34. Finding track lighting load

Step 1: Calculating load
220.43(B) and **230.42(A)(1)**
100 ft ÷ 2 ft x 150 VA x 100% = 7500 VA

Solution: The lighting track load is 7500 VA

35. Finding track lighting load

Step 1: Calculating load
220.43(B) and **230.42(A)(2)**
100 ft ÷ 2 ft x 150 VA x 125% = 9375 VA

Solution: The lighting track load is 9375 VA.

36. Finding low-voltage lighting load

Step 1: Calculating load
Article 411 and **230.42(A)(1)**
30 A x 100% = 30 A

Solution: The low-voltage lighting load is 30 amps.

37. Finding low-voltage lighting load

Step 1: Calculating load
Article 411 and **230.42(A)(2)**
30 A x 125% = 37.5 A

Solution: The low-voltage lighting load is 37.5 amps.

38. Finding outside lighting load

Step 1: Calculating load
220.14(C), 220.18(B), and **230.42(A)(1)** and **(A)(2)**
75 VA x 15 units x 125% = 1406 VA
75 VA x 15 units x 100% = <u>1125 VA</u>
Total load = 2531 VA

Solution: The outside lighting load is 2531 VA.

39. Finding outside lighting load

Step 1: Calculating load
220.18(B) and **230.42(A)(2)**
150 VA x 50 units x 125% = 9375 VA

Solution: The outside lighting load is 9375 VA.

40. Finding sign load

Step 1: Calculating load
220.14(F), 600.5(A), and **230.42(A)(2)**
1200 VA x 125% = 1500 VA

Solution: The sign load is 1500 VA.

41. Finding sign load

Step 1: Calculating load
220.14(F), 600.5(A), and **230.42(A)(2)**
2800 VA x 125% = 3500 VA

Solution: The sign load is 3500 VA.

42. Finding load for household electric range

Step 1: Calculating VA
Table 220.55, Column C
11 kW range = 8 kVA
8 kW x 1000 = 8000 VA

Solution: The total load is 8000 VA.

43. Finding load for household electric cooking units

Step 1: Finding load for cooking units
Table 220.55, Column C
10 kW and 12 kW = 11 kVA
11 kVA x 1000 = 11,000 VA

Solution: The total load is 11,000 VA.

44. Finding load for household electric ranges

Step 1: Calculating VA
Table 220.55, Column C
28 ranges = 15 kW
1 kW per range = <u>28 kW</u>
Total load = 43 kW
43 kW x 1000 = 43,000 VA

Solution: The total load is 43,000 VA.

45. Finding load for household electric ranges

Step 1: Calculating VA
Table 220.55, Column C
55 ranges = 25 kW
3/4 kW per range = <u>41.25 kW</u>
Total load = 66.25 kW

66.25 kW x 1000 = 66,250 VA

Solution: The total load is 66,250 VA.

46. Finding load for household electric cooking equipment

Step 1: Calculating VA
Table 220.55, Column A
3 kW x 80% = 2.4 kVA
2.4 kVA x 1000 = 2400 VA

Solution: The total load is 2400 VA.

47. Finding load for household electric cooking equipment

Step 1: Calculating VA
Table 220.55, Column A
3 kW x 2 units x 75% = 4.5 k VA
4.5 kVA x 1000 = 4500 VA

Solution: The total load is 4500 VA.

48. Finding load for household electric cooking equipment

Step 1: Finding percentage
Table 220.55, Column A
2.5 kW ovens = 12 units
3 kW cooktops = 12 units
Total = 24 units
24 units = 31%

Step 2: Calculating VA
Table 220.55, Column A
2.5 kW x 12 units x 31% = 9.3 kVA
3 kW x 12 units x 31% = 11.16 kVA
Total load = 20.46 kVA
20.46 kVA x 1000 = 20,460 VA

Solution: The total load is 20,460 VA

49. Finding load for household electric cooking equipment

Step 1: Calculating VA
Table 220.55, Column B
8.75 kW x 80% = 7 kVA
7 kVA x 1000 = 7000 VA

Solution: The total load is 7000 VA.

50. Finding load for household electric cooking equipment

Step 1: Calculating VA
Table 220.55, Column B
8.75 kW x 2 units x 65% = 11.375 kVA
11.375 kVA x 1000 = 11,375 VA

Solution: The total load is 11,375 VA.

51. Finding load for household electric cooking equipment

Step 1: Finding percentage
Table 220.55, Column B
8.75 kW ovens = 15 units
8.75 kW cooktops = 15 units
Total = 30 units

Step 2: Calculating VA
Table 220.55, Column B
8.75 kW x 30 units x 24% = 63 kVA
63 kVA x 1000 = 63,000 VA

Solution: The total load is 63,000 VA.

52. Finding load for household electric cooking equipment

Step 1: Finding percentage
3 kW cooktops = 10 units
8.75 ovens = 10 units
cooktops = 49% (10 units)
ovens = 34% (10 units)

Step 2: Calculating VA
Table 220.55, Columns A and **B**
3 kW x 10 units x 49% = 14.7 kVA
8.75 kW x 10 units x 34% = 29.75 kVA
Total = 44.45 kVA
44.45 kVA x 1000 = 44,450 VA

Solution: The total load is 44,450 VA.

53. Finding load for household electric range

Step 1: Calculating the percentage
Table 220.55, Note 1
16 kW - 12 kW = 4 kW
4 kW x 5% = 20%

Step 2: Calculating VA
Table 220.55, Column C
8 kW x 120% = 9.6 kVA
9.6 kVA x 1000 = 9600 VA

Solution: The total load is 9600 VA.

54. Finding load for household electric ranges

Step 1: Finding percentage
Table 220.55, Note 1
14 kW - 12 kW = 2 kW
2 kW x 5% = 10%

Step 2: Calculating VA
Table 220.55, Column C
25 ranges = 40 kW
40 kW x 110% = 44 kVA
44 kVA x 1000 = 44,000 VA

Solution: The total load is 44,000 VA.

55. Finding load for household electric cooking equipment

Step 1: Finding percentage
Table 220.55, Note 2
12 kW + 14 kW + 16 kW + 18 kW = 60 kW
60 kW x 5 = 300 kW
300 kW ÷ 20 = 15 kW

	15 kW - 12 kW	= 3 kW
	3 kW x 5%	= 15%
Step 2:	Calculating kVA	
	Table 220.55, Column C	
	20 ranges	= 35 kW
	35 kW x 115%	= 40.25 kVA
	40.25 kVA x 1000	= 40,250 VA

Solution: **The total load is 40,250 VA.**

56. Finding load for household electric cooking equipment

Step 1:	Calculating the percentage	
	Table 220.55, Note 2	
	12 kW + 14 kW + 16 kW	= 42 kW
	Average rating	
	42 kW ÷ 3	= 14
	14 kW x 5%	= 70%
Step 2:	Calculating VA	
	Table 220.55, Column C	
	14 kW x 170%	= 23.8 kVA
	23.8 kVA x 1000	= 23,800 VA

Solution: **The total load is 23,800 VA**

57. Finding the load for household electric cooking equipment

Step 1:	Calculating the percentage	
	Table 220.55, Note 4	
	12 kW + 8 kW + 4 kW	= 24 kW
	24 kW - 12 kW	= 12 kW
	12 kW x 5%	= 60%
Step 2:	Calculating VA	
	Table 220.55, Column C	
	8 kW x 160%	= 12.8 kVA
	12.8 kVA x 1000	= 12,800 VA

Solution: **The total load is 12,800 VA.**

58. Finding load for household electric dryer

Step 1:	Calculating kW	
	220.54	
	4 kW	= 5 kW
Step 2:	Applying derating factors	
	Table 220.54	
	Four of fewer dryers	= 100%
	5 kW x 100%	= 5 kW
	5 kW x 1000	= 5000 VA

Solution: **The total load is 5000 VA.**

59. Finding load for household electric dryer

Step 1:	Calculating kW	
	220.54	
	5 kW	= 5 kW
Step 2:	Applying derating factors	
	Table 220.54	
	Four of fewer dryers	= 100%
	5 kW x 100%	= 5 kW
	5 kW x 1000	= 5000 VA

Solution: **The total load is 5000 VA.**

60. Finding load for household electric dryers

Step 1:	Selecting percentage	
	Table 220.54	
	23 dryers	= 35%
Step 2:	Applying demand factors	
	Table 220.54	
	6500 VA x 23 dryers x 35%	= 52,325 VA

Solution: **The total load is 52,325 VA.**

61. Finding load for fastened-in-place (fixed) appliances

Step 1:	Totaling VA	
	220.53	
	Water heater load	= 6,000 VA
	Disposal load	= 1,400 VA
	Compactor load	= 1,050 VA
	Total load	= 8,450 VA
Step 2:	Applying demand factors	
	220.53	
	8450 VA x 100%	= 8450 VA

Solution: **The total load is 8450 VA.**

62. Finding load for fastened-in-place (fixed) appliances

Step 1:	Totaling VA - ungrounded (phase) conductors	
	220.53	
	Water heater load	= 5,000 VA
	Water pump load	= 2,600 VA
	Compactor load	= 1,050 VA
	Disposal load	= 1,200 VA
	Dishwasher load	= 1,600 VA
	Microwave load	= 1,000 VA
	Blower motor load	= 800 VA
	Total load	= 13,250 VA
Step 2:	Applying demand factors - ungrounded (phase) conductors	
	220.53	
	13,250 VA x 75%	= 9938 VA
Step 3:	Totaling VA - grounded (neutral) conductor	
	220.53	
	Compactor load	= 1,050 VA
	Disposal load	= 1,200 VA
	Dishwasher load	= 1,600 VA
	Microwave load	= 1,000 VA
	Blower motor load	= 800 VA
	Total load	= 5,650 VA
Step 4:	Applying demand factors - grounded (neutral) conductor	
	220.53	

5650 VA x 75% = 4238 VA

Solution: **The total load for the ungrounded (phase) conductors is 9938 VA and the total load for the grounded (neutral) conductor is 4238 VA.**

63. Finding load for fastened-in-place (fixed) appliances

Step 1: Totaling VA - ungrounded (phase) conductors
220.53

Water heater load	= 6,000 VA
Water pump load	= 2,200 VA
Compactor load	= 1,000 VA
Disposal load	= 1,400 VA
Dishwasher load	= 1,400 VA
Microwave load	= 1,200 VA
Blower motor load	= 1,000 VA
Total load	= 14,200 VA

Step 2: Applying demand factors - ungrounded (phase) conductors
220.53
14,200 VA x 75% = 10,650 VA

Step 3: Totaling VA - grounded (neutral) conductor
220.53

Compactor load	= 1,000 VA
Disposal load	= 1,400 VA
Dishwasher load	= 1,400 VA
Microwave load	= 1,200 VA
Total load	= 5,000 VA

Step 4: Applying demand factors - grounded (neutral) conductor
220.53
5000 VA x 75% = 3750 VA

Solution: **The total load for the ungrounded (phase) conductors is 10,650 VA and the total load for the grounded (neutral) conductor is 3750 VA.**

64. Finding load for fastened-in-place (fixed) appliances

Step 1: Totaling VA - ungrounded (phase) conductors
220.53

Water heater load	6000 VA x 20 units	= 120,000 VA
Compactor load	1200 VA x 20 units	= 24,000 VA
Disposal load	1400 VA x 20 units	= 28,000 VA
Dishwasher load	1600 VA x 20 units	= 32,000 VA
Total load		= 204,000 VA

Step 2: Applying demand factors - ungrounded (phase) conductors
220.53
204,000 VA x 75% = 153,000 VA

Step 3: Totaling VA - grounded (neutral) conductor
220.53

Compactor load	1200 VA x 20 units	= 24,000 VA
Disposal load	1400 VA x 20 units	= 28,000 VA
Dishwasher load	1600 VA x 20 units	= 32,000 VA
Total load		= 84,000 VA

Step 4: Applying demand factors - grounded (neutral) conductor
220.53
84,000 VA x 75% = 63,000 VA

Solution: **The total load for the ungrounded (phase) conductors is 153,000 VA and the total load for the grounded (neutral) conductor is 63,000 VA.**

65. Finding load for heating and air-conditioning unit

Step 1: Calculating VA
220.60
Heating load
10 kW x 100% x 1000 = 10,000 VA
A/C load
6.5 kW x 100% x 1000 = 6500 VA
Attic fan load 1.44 kW x 1000 = 1440 VA

Solution: **The total load is 10,000 VA.**

66. Finding load for heating and air-conditioning unit

Step 1: Calculating VA
220.60
Heating load
20 kW x 10 x 100% = 200 kVA
A/C load
6 kW x 10 x 100% = 60 kVA
200 kVA x 1000 = 200,000 VA

Solution: **The total load is 200,000 VA.**

67. Finding load for largest motor

Step 1: Finding FLC
Table 430.248
1 HP = 8 A

Step 2: Calculating VA
220.50, 430.22(A), and **430.24**
8 A x 240 V = 1920 VA

Solution: **The total load is 1920 VA.**

68. Finding load for largest motor

Step 1: Finding FLC
Table 430.248
1 HP = 16 A

Step 2: Calculating VA
220.50, 430.22(A), and **430.24**
16 A x 120 V = 1920 VA

Solution: **The total load is 1920 VA.**

69. Finding general purpose receptacle load

Step 1: Calculating load
220.14(I) and **230.42(A)(1)**
48 receptacles x 180 VA x 100% = 8640 VA

Solution: **The general purpose receptacle load is 8640 VA.**

70. Finding general purpose receptacle load

Step 1: Calculating load
220.14(I) and **230.42(A)(2)**
48 receptacles x 180 VA x 125% = 10,800 VA

Solution: **The general purpose receptacle load is 10,800 VA.**

71. Finding general purpose receptacle load

Step 1: Calculating load
220.14(I) and **230.42(A)(1)**
128 receptacles x 180 VA x 100% = 23,040 VA

Step 2: Applying demand factors
Table 220.44
First 10,000 VA x 100% = 10,000 VA
Next 13,040 VA x 50% = 6,520 VA
Total load = 16,520 VA

Solution: **The general purpose receptacle load is 16,520 VA.**

72. Finding multioutlet assembly load

Step 1: Calculating load
220.14(H)(1)
VA = length ÷ 5 ft x 180 VA
VA = 150 ft ÷ 5 ft x 180 VA
VA = 5400

Solution: **The multioutlet assembly load is 5400 VA.**

73. Finding multioutlet assembly load

Step 1: Calculating load
220.14(H)(2)
VA = length x 180 VA
VA = 150 ft x 180 VA
VA = 27,000

Solution: **The multioutlet assembly load is 27,000 VA.**

74. Finding special-appliance load

Step 1: Calculating VA
220.5(A)
VA = V x 1.732 (360 V) x I
VA = 208 V x 1.732 (360 V) x 68 A
VA = 24,480

Step 2: Calculating continuous load
210.19(A)(1)
24,480 VA x 125% = 30,600 VA

Solution: **The special-appliance load is 30,600 VA.**

75. Finding special-appliance load

Step 1: Calculating VA
220.5(A)
VA = V x 1.732 (360 V) x I
VA = 208 V x 1.732 (360 V) x 68 A
VA = 24,480

Step 2: Calculating noncontinuous load
210.19(A)(1)
24,480 VA x 100% = 24,480 VA

Solution: **The special-appliance load is 24,480 VA.**

76. Finding special-appliance load

Step 1: Calculating VA
220.56
8 kW x 15 = 120 kW

Step 2: Calculating amps
220.5(A)
I = (kW x 1000) ÷ (V x 1.732)
I = (120 kW x 1000) ÷ (208 V x 1.732) (360 V)
I = 333.3 A

Step 3: Applying demand factors
Table 220.56
333.3 A x 65% = 216.65 A
216.65 A x 360 V = 77,994 VA

Solution: **The special-appliance load is 77,994 VA.**

77. Finding motor load

Step 1: Finding FLC
Table 430.250
30 HP = 88 A
20 HP = 59.4 A
10 HP = 30.8 A

Step 2: Calculating total VA
220.5(A)
VA = V x 1.732 x I
30 HP motor
208 V x 1.732 (360 V) x 88 A = 31,680 VA
20 HP motor
208 V x 1.732 (360 V) x 59.4 A = 21,384 VA
10 HP motor
208 V x 1.732 (360 V) x 30.8 A = 11,088 VA
Total load = 64,152 VA

Solution: **The motor load is 64,152 VA.**

78. Finding compressor load

Step 1: Calculating load
220.5(A)
26.5 A x 4 x 480 V x 1.732 (831 V) = 88,086 VA

Step 2: Calculating total load
440.33
88,086 VA x 100% = 88,086 VA

Solution: **The compressor load is 88,086 VA.**

79. Sizing service entrance conductor for ungrounded (phase) conductors and grounded (neutral) conductor .

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
3500 sq. ft x 3 VA = 10,500 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA
Total load = 15,000 VA

Step 3: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 12,000 VA x 35% = 4,200 VA
Total load = 7,200 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C
10 kW and 11 kW = 11 kW
11 kW x 1000 = 11,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
11,000 VA x 70% = 7,700 VA √

Column 2
Calculating household electric dryer load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.54
4500 VA = 5,000 VA
5000 VA x 100% = 5,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
5000 VA x 70% = 3,500 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.530
Water heater load = 5,500 VA
Blower motor load = 1,000 VA
Water pump load = 2,600 VA
Disposal load = 1,050 VA
Compactor load = 1,200 VA
Dishwasher load = 1,600 VA
Microwave load = 1,400 VA
Total load = 14,350 VA
14,350 VA x 75% = 10,763 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.17
Disposal load = 1,050 VA
Compactor load = 1,200 VA
Dishwasher load = 1,600 VA
Microwave load = 1,400 VA
Total load = 5,250 VA
5250 VA x 75% = 3,938 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit
10,000 VA x 100% = 10,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
2600 VA x 25% = 650 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1200 VA x 25% = 300 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting and receptacle load = 7,200 VA •
Cooking equipment load = 11,000 VA •
Dryer load = 5,000 VA •
Fixed appliance load = 10,763 VA •
Heating load = 10,000 VA •
Largest motor load = 650 VA •
Total load = 44,613 VA

Calculating grounded grounded (neutral) conductor
[add neutral loads (√)]

General lighting load = 7,200 VA √
Cooking equipment load = 7,700 VA √
Dryer load = 3,500 VA √
Fixed appliance load = 3,938 VA √
Largest motor load = 300 VA √
Total load = 22,338 VA √

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 44,613 VA ÷ 240 V
I = 186 A (rounded up)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 22,338 VA ÷ 240 V
I = 93 A (rounded down)

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 186 A
Grounded (neutral) conductor = 93 A

Step 2: Selecting conductors

Table 310.16
Ungrounded (phase) conductors - Phases A and B
186 A requires 3/0 AWG THWN
Grounded (neutral) conductor
93 A requires 3 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
186 A requires 2/0 AWG THWN

Solution: The ungrounded (phase) conductors are 3/0 AWG THWN copper and the grounded (neutral) conductor is 3 AWG copper.

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
186 A requires 200 A OCPD

Solution: The size overcurrent protection device required is 200 amps.

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
186 A requires 200 A panelboard

Solution: The size panelboard required is 200 amps.

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.2679 sq. in. x 2	= .5358 sq. in.
.0973 sq. in. x 1	= .0973 sq. in.
Total sq. in. area	= .6331 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.6331 sq. in. requires 1-1/2" (41)

Solution: The size rigid metal conduit required is 1-1/2 in. (41)

80. Sizing service-entrance conductors for ungrounded (phase) conductors and grounded (neutral) conductor.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12

2800 sq. ft x 3 VA	= 8,400 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**

1500 VA x 2	= 3,000 VA
1500 VA x 1	= 1,500 VA
Total load	= 12,900 VA

Step 3: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 9900 VA x 35%	= 3,465 VA
Total load	= 6,465 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column B

8500 VA + 8750 VA	= 17,250 VA
17,250 VA x 65%	= 11,213 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)

11,213 VA x 70%	= 7,849 VA √

Column 2
Calculating household electric dryer load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.54

5500 VA	= 5,500 VA
5500 VA x 100%	= 5,500 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)

5500 VA x 70%	= 3,850 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53

Water heater load	= 6,000 VA
Blower motor load	= 1,200 VA
Water pump load	= 2,400 VA
Disposal load	= 1,400 VA
Compactor load	= 1,200 VA
Dishwasher load	= 1,600 VA
Microwave load	= 1,000 VA
Total load	= 14,800 VA
14,800 VA x 75%	= 11,100 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

Disposal load	= 1,400 VA
Compactor load	= 1,200 VA
Dishwasher load	= 1,600 VA
Microwave load	= 1,000 VA
Total load	= 5,200 VA
5000 VA x 75%	= 3,900 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit

20,000 VA x 100%	= 20,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
2400 VA x 25% = 600 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1400 VA x 25% = 350 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 6,465 VA •
Cooking equipment load	= 11,213 VA •
Dryer load	= 5,500 VA •
Fixed appliance load	= 11,100 VA •
Heating load	= 20,000 VA •
Largest motor load	= 600 VA •
Total load	= 54,878 VA

Calculating grounded (neutral) conductor
[add neutral loads (√)]

General lighting load	= 6,465 VA √
Cooking equipment load	= 7,849 VA √
Dryer load	= 3,850 VA √
Fixed appliance load	= 3,900 VA √
Largest motor load	= 350 VA √
Total load	= 22,064 VA

Finding amps for ungrounded (phase) conductors

I = VA ÷ V
I = 54,878 VA ÷ 240 V
I = 229 A (rounded up)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 22,064 VA ÷ 240 V
I = 92 A (rounded down)

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 229 A
Grounded (neutral) conductor = 92 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
229 A requires 4/0 AWG THWN
250.24(C)(1)
Grounded (neutral) conductor
92 A requires 2 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
229 A requires 4/0 AWG THWN

Solution: **The ungrounded (phase) conductors are 4/0 AWG THWN copper and the grounded (neutral) conductor is 3 AWG copper.**

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
229 A requires 250 A OCPD

Solution: **The size overcurrent protection device required is 250 amps.**

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
229 A requires 300 A panelboard

Solution: **The size panelboard required is 300 amps.**

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (minimum size)
Table 5 and **Table 4** to **Ch. 9**
.3237 sq. in. x 2 = .6474 sq. in.
.0973 sq. in. x 1 = .0973 sq. in.
Total sq. in. area = .7447 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.7447 sq. in. requires 1-1/2" (41)

Solution: **The size rigid metal conduit required is 1-1/2 in. (41)**

81. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductor.

Optional calculation
Column 1
Other load

Step 1: General lighting and receptacle load
220.82(B)(1)
3500 sq. ft x 3 VA = 10,500 VA

Step 2: Small-appliance and laundry load
220.82(B)(2)
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA

Step 3: Appliance load
220.82(B)(3) and **(B)(4)**

Cooktop load	= 10,000 VA
Oven load	= 11,000 VA
Dryer load	= 4,500 VA
Water heater load	= 5,500 VA
Blower motor load	= 1,000 VA
Water pump load	= 2,600 VA
Disposal load	= 1,050 VA
Compactor load	= 1,200 VA
Dishwasher load	= 1,600 VA
Microwave load	= 1,400 VA
Total load	= 54,850 VA

Step 4: Applying demand factors
220.82(B)

First 10,000 VA x 100%	= 10,000 VA
Next 44,850 x 40%	= 17,940 VA
Total load	= 27,940 VA

Column 2
Largest load between heating and air-conditioning load

Step 5: Selecting largest load
220.82(C)(1) and **(C)(2)** and **(C)(4)**
Heating load
10,000 VA x 65% = 6,500 VA
A/C load
6000 VA x 100% = 6,000 VA

Totaling Column 1 and 2
220.82(B) and **(C)**

Column 1 load	= 27,940 VA
Column 2 load	= 6,500 VA
Total load	= 34,440 VA

Finding amps for ungrounded (phase) conductors – Phases A and B

I = VA ÷ V
I = 34,440 VA ÷ 240 V
I = 144 A (rounded up)

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 144 A
Grounded (neutral) conductor = 94 A (problem No. 79)

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
144 A requires 1/0 AWG THWN
Grounded (neutral) conductor
93 A requires 3 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
144 A requires 1 AWG THWN

Solution: The ungrounded (phase) conductors are 1/0 AWG THWN copper and the grounded (neutral) conductor is 3 AWG THWN copper.

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
144 A requires 150 A OCPD

Solution: The size overcurrent protection device required is 150 amps.

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
144 A requires 150 A panelboard

Solution: The size panelboard required is 150 amps.

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**
.1855 sq. in. x 2 = .3710 sq. in.
.0973 sq. in. x 1 = .0973 sq. in.
Total sq. in. area = .4683 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.4683 sq. in. requires 1-1/4" (35)

Solution: The size rigid metal conduit required is 1-1/4 in. (35).

82. Sizing service-entrance conductors for ungrounded (phase) conductors and grounded (neutral) conductors

Optional calculation

Column 1
Other load

Step 1: General lighting and receptacle load
220.82(B)(1)
2,800 sq. ft x 3 VA = 8,400 VA

Step 2: Small-appliance and laundry load
220.82(B)(2)
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA

Step 3: Fixed-appliance load
220.82(B)(3) and **(B)(4)**

Cooktop load	= 8,500 VA
Oven load	= 8,750 VA
Dryer load	= 5,500 VA
Water heater load	= 6,000 VA
Blower motor load	= 1,200 VA
Water pump load	= 2,400 VA
Disposal load	= 1,400 VA
Compactor load	= 1,200 VA
Dishwasher load	= 1,600 VA
Microwave load	= 1,000 VA
Total load	= 50,450 VA

Step 4: Applying demand factors
220.82(B)

First 10,000 VA x 100%	= 10,000 VA
Next 40,450 x 40%	= 16,180 VA
Total load	= 26,180 VA

Column 2
Largest load between heating and air-conditioning load

Step 5: Selecting largest load
220.82(C)(1), (C)(2), and **(C)(4)**
Heating load
20,000 VA x 65% = 13,000 VA
A/C load

6000 VA x 100% = 6,000 VA

Totaling Column 1 and 2
220.82(B) and **(C)**

Column 1 load = 26,180 VA
Column 2 load = 13,000 VA
Total load = 39,180 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 39,180 VA ÷ 240 V
I = 163 A

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 163 A
Grounded (neutral) conductor = 93 A (problem No. 80)

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
163 A requires 2/0 AWG THWN
Grounded (neutral) conductor
93 A requires 3 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
163 A requires 1/0 AWG THWN

Solution: **The ungrounded (phase) conductors are 2/0 AWG THWN copper and the grounded (neutral) conductor 3 AWG THWN copper.**

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
163 A requires 175 A OCPD

Solution: **The size overcurrent protection device required is 175 amps.**

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
163 A requires 200 A panelboard

Solution: **The size panelboard required is 200 amps.**

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (minimum size)
Table 5 and **Table 4** to **Ch. 9**
.1855 sq. in. x 2 = 0.3710 sq. in.
.0973 sq. in. x 1 = .0973 sq. in.
Total sq. in. area = .4683 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to Ch. 9
.4683 sq. in. requires 1-1/4" (35)

Solution: **The size rigid metal conduit required is 1-1/4 in.(35)**

83. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductor

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
2800 sq. ft x 3 VA = 8,400 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA
Total load = 12,900 VA

Step 3: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 9900 VA x 35% = 3,465 VA
Total load = 6,465 VA • √

Column 2
Calculating cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column A
Total kW rating = 0

Column 2
Calculating household electric dryer load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.54
4500 VA = 5,000 VA
5000 VA x 100% = 5,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
5000 VA x 70% = 3,500 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53
Water heater load = 5,500 VA
Blower motor load = 1,000 VA
Water pump load = 2,400 VA
Disposal load = 1,000 VA
Compactor load = 1,200 VA
Dishwasher load = 1,400 VA
Microwave load = 1,000 VA
Total load = 13,500 VA

13,500 VA x 75% = 10,125 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

Disposal load	= 1,000 VA
Compactor load	= 1,200 VA
Dishwasher load	= 1,400 VA
Microwave load	= 1,000 VA
Total load	= 4,600 VA
4600 VA x 75%	= 3,450 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
A/C load
6000 VA x 100% = 6,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
2400 VA x 25% = 600 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1200 VA x 25% = 300 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 6,465 VA •
Cooking equipment load	= 0
Dryer load	= 5,000 VA •
Fixed appliance load	= 10,125 VA •
A/C load	= 6,000 VA •
Largest motor load	= 600 VA •
Total load	= 28,190 VA

Calculating grounded (neutral) conductor
[add nuetral loads (√)]

General lighting load	= 6,465 VA √
Cooking equipment load	= 0
Dryer load	= 3,500 VA √
Fixed appliance load	= 3,450 VA √
Largest motor load	= 300 VA √
Total load	= 13,715 VA

Finding amps for ungrounded (phase) conductors

I = VA ÷ V
I = 28,190 VA ÷ 240 V
I = 117 A (rounded up)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 13,715 VA ÷ 240 V
I = 57 A (rounded up)

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 117 A
Grounded (neutral) conductor = 57 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
117 A requires 1 AWG THWN
Grounded (neutral) conductor
57 A requires 6 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
117 A requires 2 AWG THWN

Solution: **The ungrounded (phase) conductors are 1 AWG THWN copper and the grounded (neutral) conductor is 6 AWG copper.**

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
117 A requires 125 A OCPD

Solution: **The size overcurrent protection device required is 125 amps.**

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
117 A requires 125 A panelboard

Solution: **The size panelboard required is 125 amps.**

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.1562 sq. in. x 2	= .3124 sq. in.
.0507 sq. in. x 1	= .0507 sq. in.
Total sq. in. area	= .3631 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.3631 sq. in. requires 1-1/4" (35)

Solution: **The size rigid metal conduit required is 1-1/4 in. (35).**

84. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductor.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
2800 sq. ft x 3 VA = 8,400 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA
Total load = 12,900 VA

Step 3: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 9900 VA x 35% = 3,465 VA
Total load = 6,465 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Note 2
14 kW + 16 kW = 30 kW
30 kW ÷ 2 = 15 kW
15 kW - 12 kW = 3 kW
3 kW x 5% = 15%
Table 220.55, Column C
Total kVA rating
11 kW x 115% x 1000 = 12,650 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
12,650 VA x 70% = 8,855 VA √

Column 2
Calculating household electric dryer load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.54
5500 VA = 5,500 VA
5500 VA x 100% = 5,500 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
5500 VA x 70% = 3,850 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53
Water heater load = 6,500 VA
Blower motor load = 1,000 VA
Water pump load = 2,200 VA
Disposal load = 1,400 VA
Compactor load = 1,200 VA
Dishwasher load = 1,400 VA
Microwave load = 1,000 VA
Total load = 14,700 VA
14,700 VA x 75% = 11,025 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.53
Disposal load = 1,400 VA
Compactor load = 1,200 VA
Dishwasher load = 1,400 VA
Microwave load = 1,000 VA
Total load = 5,000 VA
5000 VA x 75% = 3,750 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
A/C load = 6,500 VA •
Heating load = 10,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
6500 VA x 25% = 1,625 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1400 VA x 25% = 350 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load = 6,465 VA •
Cooking equipment load = 12,650 VA •
Dryer load = 5,500 VA •
Fixed appliance load = 11,025 VA •
Heating and A/C load = 16,500 VA •
Largest motor load = 1,625 VA •
Total load = 53,765 VA

Calculating grounded (neutral) conductor
[add neutral loads (√)]

General lighting load = 6,465 VA √
Cooking equipment load = 8,855 VA √
Dryer load = 3,850 VA √
Fixed appliance load = 3,750 VA √
Largest motor load = 350 VA √
Total load = 22,920 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 53,765 VA ÷ 240 V
I = 224 A (rounded down)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 22,920 VA ÷ 240 V
I = 96 A (rounded up)

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 224 A
Grounded (neutral) conductor = 96 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
224 A requires 4/0 AWG THWN
Grounded (neutral) conductor
96 A requires 3 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
224 A requires 3/0 AWG THWN

Solution: The ungrounded (phase) conductorsare 4/0 AWG THWN copper and the grounded (neutral) conductor is 3 AWG copper.

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
224 A requires 225 A OCPD

Solution: The size overcurrent protection device required is 225 amps.

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
224 A requires 225 A panelboard

Solution: The size panelboard required is 225 amps.

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (minimum size)
Table 5 and **Table 4** to **Ch. 9**
.2679 sq. in. x 2 = .5358 sq. in.
.0973 sq. in. x 1 = .0973 sq. in.
Total sq. in. area = .6331 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.6331 sq. in. requires 1-1/2 " (41)

Solution: The size rigid metal conduit required is 1-1/2 in. (41).

85. Sizing service-entrance conductors for ungrounded (phase) conductors and grounded (neutral) conductor.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
4200 sq. ft x 3 VA = 12,600 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA
Total load = 17,100 VA

Step 3: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 14,100 VA x 35% = 4,935 VA
Total load = 7,935 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Note 2
12 kW + 14 kW = 26 kW
26 kW ÷ 12 kW = 13 kW
13 kW - 12 kW = 1 kW
1 kW x 5% = 5%
Table 220.55, Column A
11 kW x 105% x 1000 = 11,550 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
11,550 VA x 70% = 8,085 VA √

Column 2
Calculating household electric dryer load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.54
5500 VA = 5,500 VA
5500 VA x 100% = 5,500 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
5500 VA x 70% = 3,850 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53
Water heater load = 6,500 VA
Blower motor load = 1,000 VA
Water pump load = 2,200 VA
Disposal load = 1,000 VA
Compactor load = 1,200 VA
Dishwasher load = 1,400 VA
Microwave load = 1,200 VA
Total load = 14,500 VA
14,500 VA x 75% = 10,875 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.53
Disposal load = 1,000 VA
Compactor load = 1,200 VA
Dishwasher load = 1,400 VA
Microwave load = 1,200 VA

Total load	=	4,800 VA
4800 VA x 75%	=	3,600 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating load
20,000 VA x 100% = 20,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
2200 VA x 25% = 550 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1200 VA x 25% = 300 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 7,935 VA •
Cooking equipment load	= 11,550 VA •
Dryer load	= 5,500 VA •
Fixed appliance load	= 10,875 VA •
Heating load	= 20,000 VA •
Largest motor load	= 550 VA •
Total load	= 56,410 VA

Calculating grounded (neutral) conductor
[add neutral loads (√)]

General lighting load	= 7,935 VA √
Cooking equipment load	= 8,085 VA √
Dryer load	= 3,850 VA √
Fixed appliance load	= 3,600 VA √
Largest motor load	= 300 VA √
Total load	= 23,470 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 56,410 VA ÷ 240 V
I = 235 A (rounded down)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 23,470 VA ÷ 240 V
I = 98 A (rounded down)

(A) Finding size ungrounded (phase) and grounded (neutral) conductors

Step 1: Calculated loads
Ungrounded (phase) conductors - Phases A and B = 235 A
Grounded (neutral) conductor = 99 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
235 A requires 250 KCMIL THWN
Grounded (neutral) conductor
98 A requires 1 AWG THWN

Step 3: Applying **Table 310.15(B)(6)**
Ungrounded (phase) conductors - Phases A and B
235 A requires 4/0 AWG THWN

Solution: **The phase ungrounded (phase) conductors are 250 KCMIL THWN copper and the grounded (neutral) conductor is 1 AWG copper.**

(B) Sizing overcurrent protection device for service conductors

Step 1: Amperage of load or conductor
240.4(A) thru (G), 240.4(B), and **240.6(A)**
235 A requires 250 A OCPD

Solution: **The size overcurrent protection device required is 250 amps.**

(C) Sizing panelboard for the service

Step 1: Amperage of load or conductor
240.4(A) thru (G) and **240.6(A)**
235 A requires 300 A panelboard

Solution: **The size panelboard required is 300 amps.**

(D) Sizing rigid metal conduit for service-entrance conductors

Step 1: Different size conductors (minimum size)
Table 5 and **Table 4** to **Ch. 9**

.3237 sq. in. x 2	= .6474 sq. in.
.0973 sq. in. x 1	= .0973 sq. in.
Total sq. in. area	= .7447 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.7447 sq. in. requires 1-1/2” (41)

Solution: **The size rigid metal conduit required is 1-1/2 in. (41)**

86. Adding water heater to existing service when applying optional calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.83(A)
2200 sq. ft x 3 VA = 6,600 VA

Step 2: Small-appliance and laundry load
Table 220.83(A)(2)
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA

Step 3: Existing load
220.83(A)(3)

Range load	= 10,000 VA
Dryer load	= 5,000 VA
Disposal load	= 1,050 VA
Compactor load	= 1,000 VA
Dishwasher load	= 1,600 VA

	Total load	= 29,750 VA
Step 4:	Applying demand factor	
	Table 220.83(A)	
	First 8000 VA x 100%	= 8,000 VA
	Next 21,750 VA x 40%	= 8,700 VA
	Total load	= 16,700 VA •
Step 5:	Calculating added load	
	Table 220.83(A)	
	Fixed appliance load	
	5000 VA x 100%	= 5,000 VA •

Totaling Columns 1 and 2
220.83(A)

Column 1 load	= 16,700 VA •
Column 2 load	= 5,000 VA •
Total load	= 21,700 VA

Finding amps for ungrounded (phase) conductors

I = VA ÷ V
I = 21,700 VA ÷ 240 V
I = 90 A
Existing service = 100 A
New calculated load = 90 A

Solution: Yes, the water heater can be added.

87. Adding air-conditioning unit to existing service when applying optional calculation

Column 1
Calculating general lighting and receptacle load

Step 1:	General lighting and receptacle load	
	Table 220.83(B)(1)	
	1800 sq. ft x 3 VA	= 5,400 VA
Step 2:	Small-appliance and laundry load	
	Table 220.83(B)(2)	
	1500 VA x 2	= 3,000 VA
	1500 VA x 1	= 1,500 VA
Step 3:	Existing load	
	Table 220.83(B)(3) and **(B)(4)**	
	Range load	= 10,000 VA
	Dryer load	= 5,000 VA
	Disposal load	= 920 VA
	Compactor load	= 1,050 VA
	Dishwasher load	= 1,600 VA
	Total load	= 28,470 VA
Step 4:	Applying demand factor	
	Table 220.83(B)	
	First 8000 VA x 100%	= 8,000 VA
	Next 20,470 VA x 40%	= 8,188 VA
	Total load	= 16,188 VA •
Step 5:	Calculating added load	
	Table 220.83(B)	
	Fixed appliance load	
	5820 VA x 100%	= 5,820 VA •

Totaling Columns 1 and 2
220.83

Column 1 load	= 16,188 VA •
Column 2 load	= 5,820 VA •
Total load	= 22,008 VA

Finding amps for ungrounded (phase) conductors

I = VA ÷ V
I = 22,008 VA ÷ 240 V
I = 92 A
Existing service = 100 A
New calculated load = 92 A

Solution: Yes, the air-conditioning unit can be added.

88. Adding air-conditioning window unit to existing service when applying optional calculation

Column 1
Calculating general lighting and receptacle load

Step 1:	General lighting and receptacle load	
	Table 220.83(B)	
	3800 sq. ft x 3 VA	= 11,400 VA
Step 2:	Small-appliance and laundry load	
	Table 220.83(B)(2)	
	1500 VA x 2	= 3,000 VA
	1500 VA x 1	= 1,500 VA
Step 3:	Existing load	
	Table 220.83(B)	
	Range load	= 10,000 VA
	Dryer load	= 5,000 VA
	Disposal load	= 1,050 VA
	Compactor load	= 1,400 VA
	Dishwasher load	= 1,600 VA
	Total load	= 34,950 VA
Step 4:	Applying demand factor	
	Table 220.83(B)	
	First 8000 VA x 100%	= 8,000 VA
	Next 26,950 VA x 40%	= 10,780 VA
	Total load	= 18,780 VA •
Step 5:	Calculating added load	
	Table 220.83(B)	
	Fixed appliance load	
	1820 VA x 3 x 100%	= 5,460 VA •

Totaling Columns 1 and 2
220.83(B)

Column 1 load	= 18,780 VA •
Column 2 load	= 5,460 VA •
Total load	= 24,240 VA

Finding amps for ungrounded (phase) conductors

I = VA ÷ V
I = 24,240 VA ÷ 240 V
I = 101 A
Existing service = 100 A
New calculated load = 101 A

Solution: No, the three air-conditioning units are not permitted to be added.

89. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductor.

Standard calculation
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
550.18(A)(1)
860 sq. ft x 3 VA = 2,580 VA

Step 2: Small-appliance and laundry load
550.18(A)(2) and **(A)(3)**
1500 VA x 2 = 3,000 VA
1500 VA x 1 = 1,500 VA
Total load = 7,080 VA

Step 3: Applying demand factor
550.18(A)(5)
First 3000 VA x 100% = 3,000 VA
Next 4080 VA x 35% = 1,428 VA
Total load = 4,428 VA • √

Calculating special load

Step 4: Applying demand factors for ungrounded (phase) conductors
550.18(B)(2), (B)(3), and **(B)(4)**
Water heater load = 5,000 VA
Disposal load = 720 VA √
Compactor load = 920 VA √
Heating load = 5,000 VA
Largest motor load = 230 VA √
(920 VA x 25%)
Total load = 11,870 VA

Calculating range load

Step 5: Applying demand factor for range load
550.18(B)(5) and **220.61(B)(1)**
8500 VA x 80% = 6,800 VA •
6800 VA x 70% = 4,760 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load = 4,428 VA •
Special-appliance load = 11,870 VA •
Range load = 6,800 VA •
Total load = 23,098 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 23,098 VA ÷ 240 V
I = 96 A

Calculating grounded (neutral) conductor
[add neutral loads (√)]

General lighting load = 4,428 VA √
Disposal load = 720 VA √
Compactor load = 920 VA √
Range load = 4,760 VA √
Largest motor load = 0 VA √
Total load = 10,828 VA

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 10,828 VA ÷ 240 V
I = 45 A

Finding conductors
Table 310.16

Ungrounded (phase) conductors - Phases and A and B = 3 AWG THWN
Grounded (neutral) conductor = 8 AWG THWN

90. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductor.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
920 sq. ft x 25 units x 3 VA = 69,000 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**
1500 VA x 25 units x 2 = 75,000 VA
1500 VA x 25 units x 1 = 37,500 VA
Total load = 181,500 VA

Step 3: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 117,000 VA x 35% = 40,950 VA
Remainder 61,500 VA x 25% = 15,375 VA
Total load = 59,325 VA • √

Column 2
Calculating cooking household electric equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C
9000 VA ranges = 40,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
40,000 VA x 70% = 28,000 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53
6000 VA x 25 units x 75% = 112,500 VA
1200 VA x 25 units x 75% = 22,500 VA
1400 VA x 25 units x 75% = 26,250 VA
Total load = 161,250 VA

•

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

1200 VA x 25 units x 75%	=	22,500 VA
1400 VA x 25 units x 75%	=	26,250 VA
Total load	=	48,750 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit
10,000 VA x 25 x 100% = 250,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
1200 VA x 25% = 300 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1200 VA x 25% = 300 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	=	59,325 VA •
Cooking equipment load	=	40,000 VA •
Fixed-appliance load	=	161,250 VA •
Heating load	=	250,000 VA •
Largest motor load	=	300 VA •
Total load	=	510,875 VA

Calculating grounded (neutral) conductor
[add neutral loads (√)]

General lighting load	=	59,325 VA √
Cooking equipment load	=	28,000 VA √
Fixed-appliance load	=	48,750 VA √
Largest motor load	=	0 VA √
Total load	=	136,075 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 510,875 VA ÷ 240 V
I = 2129 A (rounded up)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 136,075 VA ÷ 240 V
I = 567 A (rounded up)

Grounded (neutral) conductor
220.61(B)(2)
568 A

First 200 A x 100%	=	200 A
Next 367 A x 70%	=	258 A
Total load	=	458 A

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 2129 A ÷ 6
A = 355

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
355 A requires 500 KCMIL THWN

Solution: **It takes 6 – 500 KCMIL THWN copper conductors to supply a load of 2129 amps (380 A x 6 = 2280 A).**

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
2129 A requires 2000 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 2000 amps.**

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ # in parallel
A = 458 A ÷ 6
A = 76

Step 2: Selecting conductor size
Table 310.16 and **310.4**
76 A requires 1/0 AWG THWN

Solution: **It takes 6 – 1/0 AWG THWN copper conductors to supply a load of 458 amps (150 A x 6 = 900 A).**

(D) Sizing rigid metal conduit for each run

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.7073 sq. in. x 2	=	1.4146 sq. in.
.1855 sq. in. x 1	=	.1855 sq. in.
Total sq. in. area	=	1.6001 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
1.6001 sq. in. requires 2-1/2" (63)

Solution: **The size rigid metal conduit for each run is 2-1/2 in. (63).**

91. Sizing service-entrance ungrounded (phase) conductors and grounded (phase) conductor.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load

Table 220.12

720 sq. ft x 5 units x 3 VA	= 10,800 VA
860 sq. ft x 5 units x 3 VA	= 12,900 VA
940 sq. ft x 5 units x 3 VA	= 14,100 VA
980 sq. ft x 5 units x 3 VA	= 14,700 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**

1500 VA x 20 units x 2	= 60,000 VA
1500 VA x 20 units x 1	= 30,000 VA
Total load	= 142,500 VA

Step 3: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remainder 22,500 VA x 25%	= 5,625 VA
Total load	= 49,575 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C
5 - 9000 VA ranges
5 - 10,000 VA ranges
5 - 11,000 VA ranges
5 - 12,000 VA ranges
20 ranges = 35,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
35,000 VA x 70% = 24,500 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53

5500 VA x 5 units x 75%	= 20,625 VA
1050 VA x 5 units x 75%	= 3,938 VA
1000 VA x 5 units x 75%	= 3,750 VA
6000 VA x 5 units x 75%	= 22,500 VA
1200 VA x 5 units x 75%	= 4,500 VA
1200 VA x 5 units x 75%	= 4,500 VA
6000 VA x 5 units x 75%	= 22,500 VA
1000 VA x 5 units x 75%	= 3,750 VA
1400 VA x 5 units x 75%	= 5,250 VA
6500 VA x 5 units x 75%	= 24,375 VA
1200 VA x 5 units x 75%	= 4,500 VA
1600 VA x 5 units x 75%	= 6,000 VA
Total load	= 126,188 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

1050 VA x 5 units x 75%	= 3,938 VA
1000 VA x 5 units x 75%	= 3,750 VA
1200 VA x 5 units x 75%	= 4,500 VA
1200 VA x 5 units x 75%	= 4,500 VA
1000 VA x 5 units x 75%	= 3,750 VA
1400 VA x 5 units x 75%	= 5,250 VA
1200 VA x 5 units x 75%	= 4,500 VA
1600 VA x 5 units x 75%	= 6,000 VA
Total load	= 36,188 VA

√

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit

10,000 VA x 5 units x 100%	= 50,000 VA
10,000 VA x 5 units x 100%	= 50,000 VA
10,000 VA x 5 units x 100%	= 50,000 VA
12,000 VA x 5 units x 100%	= 60,000 VA
Total load	= 210,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
1200 VA x 25% = 300 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1200 VA x 25% = 300 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 49,575 VA •
Cooking equipment load	= 35,000 VA •
Fixed-appliance load	= 126,188 VA •
Heating load	= 210,000 VA •
Largest motor load	= 300 VA •
Total load	= 421,063 VA

Calculating grounded (neutral) conductor
[add neutral loads (√)]

General lighting load	= 49,575 VA √
Cooking equipment load	= 24,500 VA √
Fixed-appliance load	= 36,188 VA √
Largest motor load	= 0 VA √
Total load	= 110,263 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 421,063 VA ÷ 240 V
I = 1754 A (rounded down)

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 110,263 VA ÷ 240 V
I = 459 A (rounded up)
Neutral
220.61(B)(2)
459 A

First 200 A x 100%	= 200 A
Next 259 A x 70%	= 183 A
Total load	= 383 A

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 1754 A ÷ 6
A = 292

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors
292 A requires 350 KCMIL THWN

Solution: It takes 6 – 350 KCMIL THWN copper conductors to supply a load of 1754 amps (310 A x 6 = 1860 A).

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1754 A requires 1600 A OCPD

Solution: The size overcurrent protection device based on calculated load is 1600 amps.

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ # in parallel
A = 383 A ÷ 6
A = 64

Step 2: Selecting conductor size in parallel
250.24(C)(2), Table 310.16, and **310.4**
64 A requires 1/0 AWG THWN

Solution: It takes 6 – 1/0 AWG THWN copper conductors to supply a load of 383 amps (150 A x 6 = 900 A).

(D) Sizing rigid metal conduit for each run

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.5242 sq. in. x 2	= 1.0484 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= 1.2339 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
1.2339 sq. in. requires 2" (53)

Solution: The size rigid metal conduit for each run is 2 in. (53)

92. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductor.

Optional calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
220.84(C)(1)

920 sq. ft x 25 units x 3 VA	= 69,000 VA

Step 2: Small-appliance and laundry load
220.84(C)(2)

1500 VA x 25 units x 2	= 75,000 VA
1500 VA x 25 units x 1	= 37,500 VA
Total load	= 181,500 VA •

Column 2
Calculating household electric cooking equipment load

Step 3: Applying demand factors for ungrounded (phase) conductors
220.84(C)(3)

9000 VA x 25 units	= 225,000 VA •

Column 2
Fastened-in-place (fixed) appliance load

Step 4: Applying demand factors for ungrounded (phase) conductors
220.84(C)(3)

6000 VA x 25 units	= 150,000 VA
1200 VA x 25 units	= 30,000 VA
1400 VA x 25 units	= 35,000 VA
Total load	= 215,000 VA •

Column 3
Largest load between heating and air-conditioning load

Step 5: Selecting largest load
220.84(C)(5)
Heating unit

10,000 VA x 25 units x 100%	= 250,000 VA •

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 181,500 VA •
Cooking equipment load	= 225,000 VA •
Fixed-appliance load	= 215,000 VA •
Heating load	= 250,000 VA •
Total load	= 871,500 VA

Finding amps
220.5(A)

I = VA ÷ V
I = 871,500 VA ÷ 240 V
I = 3631 A

Finding amps for ungrounded (phase) conductors - Phases A and B
Table 220.84

I . A x %
I = 3631 A x 35%
I = 1271 A (rounded up)

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 1271 A ÷ 6
A = 212

Step 2: Selecting conductors
Table 310.16

Ungrounded (phase) conductors - Phases A and B
212 A requires 4/0 AWG THWN

Solution: **It takes 6 – 4/0 THWN copper conductors to supply a load of 1271 amps (230 A x 6 = 1380 A).**

Note: Grounded (neutral) conductors must be 6 - 1/0 AWG THWN copper conductors connected in parallel.

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1271 A requires 1200 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 1200 amps.**

(C) Sizing rigid metal conduit for each run

Step 1: Different size conductors
Table 5 and **Table 4** to **Ch. 9**

.3237 sq. in. x 2	= .6474 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= .8329 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.8329 sq. in. requires 2" (53)

Solution: **The size rigid metal conduit for each run is 2 in. (53).**

93. Sizing service-entrance ungrounded (phase) conductors grounded (neutral) conductors

Optional calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
220.84(C)(1)

720 sq. ft x 5 units x 3 VA	= 10,800 VA
860 sq. ft x 5 units x 3 VA	= 12,900 VA
940 sq. ft x 5 units x 3 VA	= 14,100 VA
980 sq. ft x 5 units x 3 VA	= 14,700 VA

Step 2: Small-appliance and laundry load
220.84(C)(2)

1500 VA x 20 units x 2	= 60,000 VA
1500 VA x 20 units x 1	= 30,000 VA
Total load	= 142,500 VA •

Column 2
Calculating household electric cooking equipment load

Step 3: Applying demand factors for ungrounded (phase) conductors
220.84(C)(3)

9000 VA x 5 units	= 45,000 VA
10,000 VA x 5 units	= 50,000 VA
11,000 VA x 5 units	= 55,000 VA
12,000 VA x 5 units	= 60,000 VA
Total load	= 210,000 VA •

Column 2
Fastened-in-place (fixed) appliance load

Step 4: Applying demand factors for ungrounded (phase) conductors
220.84(C)(3)

5500 VA x 5 units	= 27,500 VA
1050 VA x 5 units	= 5,250 VA
1000 VA x 5 units	= 5,000 VA
6000 VA x 5 units	= 30,000 VA
1200 VA x 5 units	= 6,000 VA
1200 VA x 5 units	= 6,000 VA
6000 VA x 5 units	= 30,000 VA
1000 VA x 5 units	= 5,000 VA
1400 VA x 5 units	= 7,000 VA
6500 VA x 5 units	= 32,500 VA
1200 VA x 5 units	= 6,000 VA
1600 VA x 5 units	= 8,000 VA
Total load	= 168,250 VA •

Column 3
Largest load between heating and air-conditioning load

Step 5: Selecting largest load
220.84(C)(5)
Heating unit

10,000 VA x 5 units x 100%	= 50,000 VA
10,000 VA x 5 units x 100%	= 50,000 VA
10,000 VA x 5 units x 100%	= 50,000 VA
12,000 VA x 5 units x 100%	= 60,000 VA
Total load	= 210,000 VA •

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 142,500 VA •
Cooking equipment load	= 210,000 VA •
Fixed-appliance load	= 168,250 VA •
Heating load	= 210,000 VA •
Total load	= 730,750 VA

Finding amps
220.5(A)

I = VA ÷ V
I = 730,750 VA ÷ 240 V
I = 3045 A

Finding amps for ungrounded (phase) conductors - Phases A and B

Table 220.84

I = A x %
I = 3045 A x 38%
I = 1157 A (rounded down)

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 1157 A ÷ 6
A = 193

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B

193 A requires 3/0 AWG THWN

Solution: **It takes 6 – 3/0 AWG THWN copper conductors to supply a load of 1157 amps (200 A x 6 = 1200 A).**

Note: Grounded (neutral) conductors must be 6 – 1/0 AWG THNN copper conductors in parallel.

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1157 A requires 1000 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 1000 amps.**

(C) Sizing rigid metal conduit for each run

Step 1: Different size conductors
Table 5 and **Table 4** to **Ch. 9**

.2679 sq. in. x 2	= .5358 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= .7213 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.7213 sq. in. requires 1-1/2" (41)

Solution: **The size rigid metal conduit for each run is 1-1/2 in. (41).**

94. Sizing service-entrance conductors for ungrounded (phase) conductors and grounded (neutral) conductors

Optional calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
220.84(C)(1)

720 sq. ft x 5 units x 3 VA	= 10,800 VA
860 sq. ft x 5 units x 3 VA	= 12,900 VA
940 sq. ft x 5 units x 3 VA	= 14,100 VA
980 sq. ft x 5 units x 3 VA	= 14,700 VA

Step 2: Small-appliance and laundry load
220.84(C)(2)

1500 VA x 20 units x 2	= 60,000 VA
1500 VA x 20 units x 1	= 30,000 VA
Total load	= 142,500 VA •

Column 2
Calculating household electric cooking equipment load

Step 3: Applying demand factors for ungrounded (phase) conductors
220.84(C)(3)

9000 VA x 5 units	= 45,000 VA
10,000 VA x 5 units	= 50,000 VA
11,000 VA x 5 units	= 55,000 VA
12,000 VA x 5 units	= 60,000 VA
Total load	= 210,000 VA •

Column 2

Fastened-in-place (fixed) appliance load

Step 4: Applying demand factors for ungrounded (phase) conductors
220.84(C)(3)

5500 VA x 5 units	= 27,500 VA
1050 VA x 5 units	= 5,250 VA
1000 VA x 5 units	= 5,000 VA
6000 VA x 5 units	= 30,000 VA
1200 VA x 5 units	= 6,000 VA
1200 VA x 5 units	= 6,000 VA
6000 VA x 5 units	= 30,000 VA
1000 VA x 5 units	= 5,000 VA
1400 VA x 5 units	= 7,000 VA
6500 VA x 5 units	= 32,500 VA
1200 VA x 5 units	= 6,000 VA
1600 VA x 5 units	= 8,000 VA
Total load	= 168,250 VA •

Column 3
Largest load between heating and air-conditioning load

Step 5: Selecting largest load
220.84(C)(5)
Heating unit

10,000 VA x 5 units x 100%	= 50,000 VA
10,000 VA x 5 units x 100%	= 50,000 VA
10,000 VA x 5 units x 100%	= 50,000 VA
12,000 VA x 5 units x 100%	= 60,000 VA
Total load	= 210,000 VA •

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 142,500 VA •
Cooking equipment load	= 210,000 VA •
Fixed appliance load	= 168,250 VA •
Heating load	= 210,000 VA •
Total load	= 730,750 VA

Finding amps
220.5(A)

I = VA ÷ V
I = 730,750 VA ÷ 240 V
I = 3045 A

Finding amps for ungrounded (phase) conductors - Phases A and B
Table 220.84

I = A x %
I = 3045 A x 38%
I = 1157 A (rounded down)

(A) Finding ampacity of the house loads

Step 1: Finding total house loads
220.84(B)
Laundry loads
210.52(F), Ex. 1 and **230.42(A)(1)**
38,675 VA x 100% = 38,675 VA
Outside lighting loads
220.18(B) and **230.42(A)(2)**
30 units x 180 VA x 125% = 6,750 VA
Outside receptacle loads
220.14(I) and **Table 220.44**

30 receptacles x 180 VA x 100%	= 5,400 VA
Outside sign loads	
220.14(F) and **600.5(A)**	
1800 VA x 125%	= 2,250 VA
Total load	= 53,075 VA

Step 2: Finding ampacity
Text
I = VA ÷ (V x √3)
I = 53,075 VA ÷ (208 V x 1.732) (360 V)
I = 147.4 A

Solution: **The amperage is 147.4 amps for the house loads.**

(B) Finding ampacity for ungrounded (phase) conductors and the grounded (neutral) conductors

Step 1: Finding ampacity for ungrounded (phase) conductors
220.40

Apartment loads	= 1157 A
House loads	= 147.4 A
Total loads	= 1304.4 A

Solution: **The ampacity for the ungrounded (phase) conductors is 1304.4 amps.**

Step 1: Finding ampacity for grounded (neutral) conductors (house loads)
220.61(B)(1)

Outside lighting loads	= 5,400 VA
Outside receptacle loads	= 5,400 VA
Outside sign loads	= 1,800 VA
Total loads	= 12,600 VA

Step 2: Calculating ampacity for grounded (neutral) conductors (house loads)
220.61(B)(1) and **220.5(A)**
12,600 VA ÷ 240 V = 52.5 A

Step 3: Finding ampacity for grounded (neutral) conductors (total)
220.61(B)(1); Problem 91 (see page 76)

Apartment loads	= 383 A
House loads	= 52.5 A
Total loads	= 435.5 A

Solution: **The ampacity for the grounded (neutral) conductors is 435.5 amps.**

95. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductors.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
860 sq. ft x 20 units x 3 VA = 51,600 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**

1500 VA x 20 units x 2	= 60,000 VA
1500 VA x 20 units x 1	= 30,000 VA
Total load	= 141,600 VA

Step 3: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 117,000 VA x 35%	= 40,950 VA
Remainder 21,600 VA x 25%	= 5,400 VA
Total load	= 49,350 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C
Ranges = 0 (gas related)

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53

6500 VA x 20 units x 75%	= 97,500 VA
1050 VA x 20 units x 75%	= 15,750 VA
1400 VA x 20 units x 75%	= 21,000 VA
Total load	= 134,250 VA

•

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

1050 VA x 20 units x 75%	= 15,750 VA
1400 VA x 20 units x 75%	= 21,000 VA
Total load	= 36,750 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit
Heating units = 0 (gas related)

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
1050 VA x 25% = 263 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1050 VA x 25% = 263 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 49,350 VA •
Cooking equipment load	= 0
Fixed-appliance load	= 134,250 VA •
Heating load	= 0
Largest motor load	= 263 VA •
Total load	= 183,863 VA

Calculating grounded (neutral) conductors
[add neutral loads (√)]

General lighting load	= 49,350 VA √
Cooking equipment load	= 0
Fixed-appliance load	= 36,750 VA √
Largest motor load	= 0 VA
Total load	= 86,100 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 183,863 VA ÷ 240 V
I = 766 A (rounded down)

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 86,100 VA ÷ 240 V
I = 359 A (rounded up)

Grounded (neutral) conductors
220.61(B)(1)

360 A	
First 200 A x 100%	= 200 A
Next 159 A x 70%	= 112 A
Total load	= 312 A

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 766 A ÷ 3
A = 255.3 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
255.3 A requires 250 KCMIL THWN

Solution: **It takes 3 – 250 KCMIL THWN copper conductors to supply a load of 766 amps (255 A x 3 = 765 A).**

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD based on load calculation
230.90(A), 240.4(B), and **240.6(A)**
766 A requires 800 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 800 amps.**

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ # in parallel
A = 312 A ÷ 3
A = 104

Step 2: Selecting conductor size
Table 310.16, 250.24(C)(2), and **310.4**
104 A requires 1/0 AWG THWN

Solution: **It takes 3 – 1/0 AWG THWN copper conductors to supply a load of 312 amps (150 A x 3 = 450 A).**

(D) Sizing rigid metal conduit for each run

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.3970 sq. in. x 2	= .7940 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= .9795 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
.9795 sq. in. requires 2" (53)

Solution: **The size rigid metal conduit for each run is 2 in. (53)**

96. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductors.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12

920 sq. ft x 15 units x 3 VA	= 41,400 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**

1500 VA x 15 units x 2	= 45,000 VA
1500 VA x 15 units x 1	= 22,500 VA
Total load	= 108,900 VA

Step 3: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 105,900 VA x 35%	= 37,065 VA
Total load	= 40,065 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C

11,000 VA ranges	= 30,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)

30,000 VA x 70%	= 21,000 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53

5500 VA x 15 units x 75%	= 61,875 VA

1000 VA x 15 units x 75%	=	11,250 VA
1600 VA x 15 units x 75%	=	18,000 VA
Total load	=	91,125 VA •

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

1000 VA x 15 units x 75%	=	11,250 VA
1600 VA x 15 units x 75%	=	18,000 VA
Total load	=	29,250 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit
10,000 VA x 15 units x 100% = 150,000 VA •
A/C units
5160 VA x 15 units x 100% = 77,400 VA √

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
1920 VA x 25% = 480 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1920 VA x 25% = 480 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	=	40,065 VA •
Cooking equipment load	=	30,000 VA •
Fixed-appliance load	=	91,125 VA •
Heating load	=	150,000 VA •
Largest motor load	=	480 VA •
Total load	=	311,670 VA

Calculating grounded (neutral) conductors
[add neutral loads (√)]

General lighting load	=	40,065 VA √
Cooking equipment load	=	21,000 VA √
Fixed-appliance load	=	29,250 VA √
Air-conditioning load	=	77,400 VA √
Largest motor load	=	0 VA
Total load	=	167,715 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 311,670 VA ÷ 240 V
I = 1299 A (rounded up)

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 167,715 VA ÷ 240 V
I = 699 A (rounded up)

Grounded (neutral) conductors
220.61(B)(1)
699 A

First 200 A x 100%	= 200 A
Next 499 A x 70%	= 351 A
Total load	= 551 A

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ number in parallel
A = 1299 A ÷ 4
A = 325 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
325 A requires 400 AWG KCMIL THWN cu.

Solution: **It takes 4 – 400 KCMIL THWN copper conductors to supply a load of 1298 amps (335 A x 4 = 1340 A).**

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1299 A requires 1200 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 1200 amps.**

(C) Finding size grounded (neutral) conductors

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ number in parallel
A = 551 A ÷ 4
A = 138

Step 2: Selecting conductor size
Table 310.16 and **310.4**
138 A requires 1/0 AWG THWN

Solution: **It takes 4 – 1/0 AWG THWN copper conductors to supply a load of 551 amps (150 A x 4 = 600 A).**

(D) Sizing rigid PVC (Schedule 80) conduit for each run

Step 1: Different size conductors
Table 5 and **Table 4** to **Ch. 9**

.5863 sq. in. x 2	= 1.1726 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= 1.3581 sq. in.

Step 2: Selecting size PVC conduit
Table 4 to **Ch. 9**
1.3581 sq. in. requires 2-1/2” (63)

Solution: **The size rigid PVC conduit (schedule 80) for each run is 2-1/2 in. (63)**

97. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductors.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12
1280 sq. ft x 10 units x 3 VA = 38,400 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**
1500 VA x 10 units x 2 = 30,000 VA
1500 VA x 10 units x 1 = 15,000 VA
Total load = 83,400 VA

Step 3: Applying demand factors
Table 220.42
First 3000 VA x 100% = 3,000 VA
Next 80,400 VA x 35% = 28,140 VA
Total load = 31,140 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C
10,000 VA ranges = 25,000 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)
25,000 VA x 70% = 17,500 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53
6000 VA x 10 units x 75% = 45,000 VA
1000 VA x 10 units x 75% = 7,500 VA
1400 VA x 10 units x 75% = 10,500 VA
Total load = 63,000 VA

•

Step 2: Applying derating factors for grounded (neutral) conductor
220.53
1000 VA x 10 units x 75% = 7,500 VA
1400 VA x 10 units x 75% = 10,500 VA
Total load = 18,000 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit
26,250 VA x 10 units x 100% = 262,500 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**
6250 VA x 25% = 1,563 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**
1000 VA x 25% = 250 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 31,140 VA •
Cooking equipment load	= 25,000 VA •
Fixed-appliance load	= 63,000 VA •
Heating load	= 262,500 VA •
Largest motor load	= 1,563 VA •
Total load	= 383,203 VA

Calculating grounded (neutral) conductors
[add neutral loads (√)]

General lighting load	= 31,140 VA √
Cooking equipment load	= 17,500 VA √
Fixed-appliance load	= 18,000 VA √
Largest motor load	= 0 VA
Total load	= 66,640 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 383,203 VA ÷ 240 V
I = 1597 A (rounded up)

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 66,640 VA ÷ 240 V
I = 278 A (rounded up)

Grounded (neutral) conductors

220.61(B)(1)
278 A
First 200 A x 100% = 200 A
Next 78 A x 70% = 55 A
Total load = 255 A

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ number in parallel
A = 1597 A ÷ 4
A = 399 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
399 A requires 600 KCMIL THWN

Solution: **It takes 4 – 600 KCMIL THWN copper conductors to supply a load of 1597 amps (420 A x 4 = 1680 A).**

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**

1597 A requires 1500 A OCPD

Solution: The size overcurrent protection device based on calculated load is 1500 amps.

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ number in parallel
A = 255 A ÷ 4
A = 64

Step 2: Selecting conductor size
Table 310.16, 250.24(C)(2), and **310.4**
64 A requires 1/0 AWG THWN

Solution: It takes 4 – 1/0 AWG THWN copper conductors to supply a load of 255 amps (150 A x 4 = 600 A).

(D) Sizing rigid metal conduit for each run

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.8676 sq. in. x 2	= 1.7352 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= 1.9207 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
1.9207 sq. in. requires 3" (78)

Solution: The size rigid metal conduit for each run is 3 in. (78).

98. Sizing service-entrance ungrounded (phase) conductors and grounded (neutral) conductors.

Standard calculation

Column 1
Calculating general lighting and receptacle load

Step 1: General lighting and receptacle load
Table 220.12

1020 sq. ft x 15 units x 3 VA	= 45,900 VA

Step 2: Small-appliance and laundry load
220.52(A) and **(B)**

1500 VA x 15 units x 2	= 45,000 VA
1500 VA x 15 units x 1	= 22,500 VA
Total load	= 113,400 VA

Step 3: Applying demand factors
Table 220.42

First 3000 VA x 100%	= 3,000 VA
Next 110,400 VA x 35%	= 38,640 VA
Total load	= 41,640 VA • √

Column 2
Calculating household electric cooking equipment load

Step 1: Applying demand factors for ungrounded (phase) conductors
Table 220.55, Column C

# = 15 ranges ÷ 3Ø	= 5
# 5 ranges per phase x 2	= 10
10 ranges	= 25 kW
25 kW x 1000	= 25,000 VA
25,000 VA ÷ 2 phases x 3Ø	= 37,500 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)

37,500 VA x 70%	= 26,250 VA √

Column 2
Calculating household electric dryer load

Step 1: Applying demand factors for ungrounded (phase) conductors
220.54 and **Table 220.54**

# = 15 dryers ÷ 3Ø	= 5
# 5 dryers per phase x 2	= 10
5 kW x 20 x 50%	= 25 kW
25 kW x 1000	= 25,000 VA
25,000 VA ÷ 2 phases x 3Ø	= 37,500 VA •

Step 2: Applying demand factors for grounded (neutral) conductor
220.61(B)(1)

37,500 VA x 70%	= 26,250 VA √

Column 2
Calculating fastened-in-place (fixed) appliance load

Step 1: Applying derating factors for ungrounded (phase) conductors
220.53

6500 VA x 15 units x 75%	= 73,125 VA
1050 VA x 15 units x 75%	= 11,813 VA
1400 VA x 15 units x 75%	= 15,750 VA
1960 VA x 15 units x 75%	= 22,050 VA
Total load	= 122,738 VA

Step 2: Applying derating factors for grounded (neutral) conductor
220.53

1050 VA x 15 units x 75%	= 11,813 VA
1400 VA x 15 units x 75%	= 15,750 VA
1960 VA x 15 units x 75%	= 22,050 VA
Total load	= 49,613 VA √

Column 3
Largest load between heating and air-conditioning load

Step 1: Selecting largest load
220.60
Heating unit

10,000 VA x 15 units x 100%	= 150,000 VA •

Column 4
Calculating largest motor load

Step 1: Selecting largest motor load for ungrounded (phase) conductors
220.50 and **430.24**

1050 VA x 25%	= 263 VA •

Step 2: Selecting largest motor load for grounded (neutral) conductor
220.50 and **430.24**

1050 VA x 25%	= 263 VA √

Calculating ungrounded (phase) conductors
[add phase loads (•)]

General lighting load	= 41,640 VA •
Cooking equipment load	= 37,500 VA •
Dryer load	= 37,500 VA •
Fixed-appliance load	= 122,738 VA •
Heating load	= 150,000 VA •
Largest motor load	= 263 VA •
Total load	= 389,641 VA

Calculating grounded (neutral) conductors
[add neutral loads (√)]

General lighting load	= 41,640 VA √
Cooking equipment load	= 26,250 VA √
Dryer load	= 26,250 VA √
Fixed-appliance load	= 49,613 VA √
Largest motor load	= 0 VA
Total load	= 143,753 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 389,641 VA ÷ 360 V
I = 1082 A (rounded down)

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 143.753 VA ÷ 360 V
I = 399 A (rounded down)

Grounded (neutral) conductors
220.61(B)(1)
399 A

First 200 A x 100%	= 200 A
Next 199 A x 70%	= 140 A
Total load	= 340 A

(A) Finding size ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ number in parallel
A = 1082 A ÷ 4
A = 271 A

Step 2: Selecting conductors
Table 310.16
Ungrounded (phase) conductors - Phases A and B
271 A requires 4 - 300 KCMIL THWN

Solution: **It takes 4 – 300 KCMIL THWN copper conductors to supply a load of 1082 amps (285 A x 4 = 1140 A).**

(B) Sizing overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1082 A requires 1000 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 1000 amps.**

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ number in parallel
A = 340 A ÷ 4
A = 85

Step 2: Selecting conductor size
Table 310.16 and **310.4**
85 A requires 1/0 AWG THWN

Solution: **It takes 4 – 1/0 AWG THWN copper conductors to supply a load of 340 amps (150 A x 4 = 600 A).**

(D) Sizing rigid metal conduit for each run

Step 1: Different size conductors (maximum size)
Table 5 and **Table 4** to **Ch. 9**

.4608 sq. in. x 3	= 1.3824 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in. area	= 1.5679 sq. in.

Step 2: Selecting size rigid metal conduit
Table 4 to **Ch. 9**
1.5679 sq. in. requires 2-1/2" (63)

Solution: **The size rigid metal conduit for each run is 2-1/2 in. (63).**

99. Calculating load in VA and amps for a store building including warehouse space - standard calculation (120/240 volt, single.phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**

60,000 sq. ft x 3 VA	= 180,000 VA √
180,000 VA x 125%	= 225,000 VA •
30,000 sq. ft x 1/4 VA	= 7,500 VA √
7500 VA x 125%	= 9,375 VA •

Step 2: Show window load
220.14(G) and **220.43(A)**
120 ft x 200 VA = 24,000 VA •

Step 3: Track lighting load
220.43(B) and **410.15(B)**
120 ft ÷ 2 ft x 150 VA = 9,000 VA • √

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**

50 ballasts x 180 VA	= 9,000 VA √
9000 VA x 125%	= 11,250 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**

2400 VA x 100%	= 2,400 VA √
2400 VA x 125%	= 3,000 VA •
Total load	= 281,625 VA *

Calculating receptacle load

Step 1: Noncontinuous operation

220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**

82 receptacles x 180 VA	= 14,760 VA
160 ft x 180 VA	= 28,800 VA
Total load	= 43,560 VA
Table 220.44	
First 10,000 VA x 100%	= 10,000 VA
Next 33,560 VA x 50%	= 16,780 VA
Total load	= 26,780 VA • √

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**

30 receptacles x 180 VA	= 5,400 VA √
5400 VA x 125%	= 6,750 VA •
Total load	= 33,530 VA *

Calculating special load

Step 1: Water heater load
220.14(A)
18,000 VA x 100% = 18,000 VA • *

Calculating compressor load

Step 1: Freezer load
2210.14(C), 220.50, and **230.42(A)(1)**
8640 VA x 100% = 8,640 VA •

Step 2: Ice cream box load
220.14(C), 220.50, and **230.42(A)(1)**
5820 VA x 100% = 5,820 VA •

Step 3: Walk-in cooler
220.14(C), 220.50, and **230.42(A)(1)**

9680 VA x 100%	= 9,680 VA •
Total load	= 24,140 VA *

Calculating motor load

Step 1: Water pump load
220.14(C), 220.50, 430.24, and **Table 430.248**
12 A x 240 V x 100% = 2,880 VA •

Step 2: Exhaust fan load
220.14(C), 220.50, 430.24, and **Table 430.248**

6.9 A x 240 V x 100%	= 1,656 VA •
Total load	= 4,536 VA *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
50,000 VA x 100% = 50,000 VA • *

Calculating largest motor load

Step 1: Walk-in cooler load
220.14(C), 220.50, and **430.24**
9680 VA x 25% = 2,420 VA • *

Calculating ungrounded (phase) conductors
[add phase loads (•)]

Lighting loads	= 281,625 VA •
Receptacle loads	= 33,530 VA •
Special loads	= 18,000 VA •
Compressor loads	= 24,140 VA •
Motor loads	= 4,536 VA •
Heating load	= 50,000 VA •
Largest motor load	= 2,420 VA •
Total load	= 414,251 VA

Calculating grounded (neutral) conductors
[add neutral loads (√)]

Lighting load	= 231,900 VA √
Receptacle load	= 32,180 VA √
Total load	= 264,080 VA

Finding amps for ungrounded (phase) conductors - Phases A and B

I = VA ÷ V
I = 414,251 VA ÷ 240 V
I = 1726 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 264,080 VA ÷ 240 V
I = 1100 A

(A) Finding ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 1726 A ÷ 6
A = 288

Step 2: Selecting conductor size
Table 310.16
288 A requires 350 KCMIL THWN
350 KCMIL = 310 A

Solution: It takes 6 – 350 KCMIL THWN copper conductors to supply a load of 1726 amps (310 A x 6 = 1860 A).

(B) Finding overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1860 A requires 1600 A OCPD

Solution: The size overcurrent protection device based on calculated load is 1600 amps.

(C) Finding size grounded (neutral) conductors

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ number in parallel
A = 1100 A ÷ 6
A = 183

Step 2: Selecting conductor size
Table 310.16
183 A requires 3/0 AWG cu.
3/0 AWG cu. = 200 A

Solution: It takes 6 – 3/0 AWG THWN copper conductors to supply

a load of 1100 amps (200 A x 6 = 1200 A).

(D) Sizing rigid metal conduit for each run

Step 1: Sizing sq. in. area
Table 5, Ch. 9
350 KCMIL = .5242 sq. in.
3/0 AWG THWN = .2679 sq. in.

Step 2: Calculating total sq. in. area
Table 5, Ch. 9

.5242 sq. in. x 2	= 1.0484 sq. in.
.2679 sq. in. x 1	= .2679 sq. in.
Total sq. in.	= 1.3163 sq. in.

Step 3: Selecting rigid metal conduit
Table 4, Ch. 9
1.3163 sq. in. requires 2" (53)

Solution: The size rigid metal conduit for each run is 2 in. (53)

100. Calculating load in VA and amps for a store building including warehouse space - standard calculation (120/208 volt, three.phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**

60,000 sq. ft x 3 VA	= 180,000 VA √
180,000 VA x 125%	= 225,000 VA •
30,000 sq. ft x 1/4 VA	= 7,500 VA √
7500 VA x 125%	= 9,375 VA •

Step 2: Show window load
220.14(G) and **220.43(A)**
120 ft x 200 VA = 24,000 VA • √

Step 3: Track lighting load
220.43(B) and **410.151(B)**
120 ft ÷ 2 ft x 150 VA = 9,000 VA • √

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**

50 ballasts x 180 VA	= 9,000 VA √
9000 VA x 125%	= 11,250 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**

2400 VA x 100%	= 2,400 VA √
2400 VA x 125%	= 3,000 VA •
Total load	= 281,625 VA *

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**

82 receptacles x 180 VA	= 14,760 VA
160 ft x 180 VA	= 28,800 VA
Total load	= 43,560 VA

Table 220.44

First 10,000 VA x 100%	= 10,000 VA
Next 33,560 VA x 50%	= 16,780 VA
Total load	= 26,780 VA • √

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**

30 receptacles x 180 VA	= 5,400 VA √
5400 VA x 125%	= 6,750 VA •
Total load	= 33,530 VA *

Calculating special load

Step 1: Water heater load
220.14(A)
18,000 VA x 100% = 18,000 VA • *

Calculating compressor load

Step 1: Freezer load
220.14(C), 220.50, and **230.42(A)(1)**
8640 VA x 100% = 8,640 VA •

Step 2: Ice cream box load
220.14(C), 220.50, and **230.42(A)(1)**
5820 VA x 100% = 5,820 VA •

Step 3: Walk-in cooler
220.14(C), 220.50, and **230.42(A)(1)**

9680 VA x 100%	= 9,680 VA •
Total load	= 24,140 VA *

Calculating motor load

Step 1: Water pump load
220.14(C), 220.50, 430.24, and **Table 430.250**
7.5 A x 360 V x 100% = 2,700 VA •

Step 2: Exhaust fan load
220.14(C), 220.50, 430.24, and **Table 430.250**

3.5 A x 360 V x 100%	= 1,260 VA •
Total load	= 3,960 VA *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
50,000 VA x 100% = 50,000 VA • *

Calculating largest motor load

Step 1: Walk-in cooler load
220.14(C), 220.50, and **430.24**
9680 VA x 25% = 2,420 VA • *

Calculating ungrounded (phase) conductors [add phase loads (•)]

Lighting loads	= 281,625 VA •
Receptacle loads	= 33,530 VA •
Special loads	= 18,000 VA •
Compressor loads	= 24,140 VA •
Motor loads	= 3,960 VA •
Heating load	= 50,000 VA •
Largest motor load	= 2,420 VA •

Total load = 413,675 VA

Calculating grounded (neutral) conductors
[add neutral loads (√)]

Lighting load = 231,900 VA √
Receptacle load = 32,180 VA √
Total load = 264,080 VA

Finding amps for ungrounded (phase) conductors - Phases A, B, and C

I = VA ÷ V
I = 413,675 VA ÷ 360 V
I = 1149 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 264,080 VA ÷ 360 V
I = 734 A

(A) Finding ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 1149 A ÷ 6
A = 192

Step 2: Selecting conductor size
Table 310.16
192 A requires 3/0 AWG THWN
3/0 AWG THWN = 200 A

Solution: **It takes 6 – 3/0 AWG THWN copper conductors to supply a load of 1149 amps (200 A x 6 = 1200 A).**

(B) Finding overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(B), and **240.6(A)**
1149 A requires 1000 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 1000 amps.**

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ number in parallel
A = 734 A ÷ 6
A = 122

Step 2: Selecting conductor size
Table 310.16
122 A requires 1/0 AWG cu.
1/0 AWG cu. = 150 A

Solution: **It takes 6 – 1/0 AWG THWN copper conductors to supply a load of 734 amps (150 A x 6 = 900 A).**

(D) Sizing rigid metal conduit for each run

Step 1: Sizing sq. in. area
Table 5, Ch. 9
3/0 AWG THWN = .2679 sq. in.
1/0 AWG THWN = .1855 sq. in.

Step 2: Calculating total sq. in. area
Table 5, Ch. 9
.2679 sq. in. x 3 = .8037 sq. in.
.1855 sq. in. x 1 = .1855 sq. in.
Total sq. in. = .9892 sq. in.

Step 3: Selecting rigid metal conduit
Table 4, Ch. 9
.9892 sq. in. requires 2” (53)

Solution: **The size rigid metal conduit for each run is 2 in. (53).**

101. Calculating load in VA and amps for a store building including warehouse space - standard calculation (277/480 volt, three.phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**
60,000 sq. ft x 3 VA = 180,000 VA √
180,000 VA x 125% = 225,000 VA •
30,000 sq. ft x 1/4 VA = 7,500 VA √
7500 VA x 125% = 9,375 VA •

Step 2: Show window load
220.14(G) and **220.43(A)**
120 ft x 200 VA = 24,000 VA •

Step 3: Track lighting load
220.43(B) and **410.51(B)**
120 ft ÷ 2 ft x 150 VA = 9,000 VA •

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**
50 ballasts x 180 VA = 9,000 VA
9000 VA x 125% = 11,250 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**
2400 VA x 100% = 2,400 VA
2400 VA x 125% = 3,000 VA •
Total load = 281,625 VA *

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**
82 receptacles x 180 VA = 14,760 VA
160 ft x 180 = 28,800 VA
Total load = 43,560 VA
Table 220.44
First 10,000 VA x 100% = 10,000 VA
Next 33,560 VA x 50% = 16,780 VA
Total load = 26,780 VA •

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**
30 receptacles x 180 VA = 5,400 VA
5400 VA x 125% = 6,750 VA •
Total load = 33,530 VA *

Calculating special load

Step 1: Water heater load
22.14(A)
18,000 VA x 100% = 18,000 VA • *

Calculating compressor load

Step 1: Freezer load
220.14(C), 220.50, and **230.42(A)(1)**
8640 VA x 100% = 8,640 VA •

Step 2: Ice cream box load
220.14(C), 220.50, and **230.42(A)(1)**
5820 VA x 100% = 5,820 VA •

Step 3: Walk-in cooler
220.14(C), 220.50, and **230.42(A)(1)**
9680 VA x 100% = 9,680 VA •
Total load = 24,140 VA *

Calculating motor load

Step 1: Water pump load
220.14(C), 220.50, 430.24 and **Table 430.250**
3.4 A x 831 V x 100% = 2,825 VA •

Step 2: Exhaust fan load
220.14(C), 220.50, 430.24, and **Table 430.250**
1.6 A x 831 V x 100% = 1,330 VA •
Total load = 4,155 VA *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
50,000 VA x 100% = 50,000 VA • *

Calculating largest motor load

Step 1: Walk-in cooler load
220.14(C), 220.50, and **430.24**
9680 VA x 25% = 2,420 VA • *

Calculating ungrounded (phase) conductors [add phase loads (•)]

Lighting loads	= 281,625 VA •
Receptacle loads	= 33,530 VA •
Special loads	= 18,000 VA •
Compressor loads	= 24,140 VA •
Motor loads	= 4,155 VA •
Heating load	= 50,000 VA •
Largest motor load	= 2,420 VA •
Total load	= 413,870 VA

Calculating grounded (neutral) conductors [add neutral loads (√)]

Lighting load = 187,500 VA √

Finding amps for ungrounded (phase) conductors – Phases A, B, and C

I = VA ÷ V
I = 413,870 VA ÷ 831 V
I = 498 A

Finding amps for grounded (neutral) conductor

I = VA ÷ V
I = 187,500 VA ÷ 831 V
I = 226 A

(A) Finding ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ # in parallel
A = 498 A ÷ 2
A = 249

Step 2: Selecting conductor size
Table 310.16
249 A requires 250 KCMIL THWN
250 KCMIL = 255 A

Solution: **It takes 2 – 250 KCMIL THWN copper conductors to supply a load of 498 amps (255 A x 2 = 510 A).**

(B) Finding overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(B), and **240.6(A)**
510 A requires 500 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 500 amps.**

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ # in parallel
A = 226 A ÷ 2
A = 113

Step 2: Selecting conductor size
Table 310.16
113 A requires 1/0 AWG cu.
1/0 AWG cu. = 150 A

Solution: **It takes 2 – 1/0 AWG THWN copper conductors to supply a load of 226 amps (150 A x 2 = 300 A).**

(D) Sizing rigid metal conduit for each run

Step 1: Sizing sq. in. area
Table 5, Ch. 9
250 KCMIL = .397 sq. in.
1/0 AWG THWN = .1855 sq. in.

Step 2: Calculating total sq. in. area
Table 5, Ch. 9

.397 sq. in. x 3	= 1.191 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in.	= 1.3765 sq. in.

Step 3: Selecting rigid metal conduit
Table 4, Ch. 9
1.3765 sq. in. requires 2-1/2" (63)

Solution: The size rigid metal conduit for each run is 2-1/2 in. (63).

102. Calculating load in VA and amps for a store building including warehouse space - standard calculation (120/240 volt, three.phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**

60,000 sq. ft x 3 VA	= 180,000 VA √
180,000 VA x 125%	= 225,000 VA •
30,000 sq. ft x 1/4 VA	= 7,500 VA √
7500 VA x 125%	= 9,375 VA •

Step 2: Show window load
220.14(G) and **220.43(A)**
120 ft x 200 VA = 24,000 VA • √

Step 3: Track lighting load
220.43(B) and **410.151(B)**
120 ft ÷ 2 ft x 150 VA = 9,000 VA • √

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**

50 ballasts x 180 VA	= 9,000 VA √
9000 VA x 125%	= 11,250 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**

2400 VA x 100%	= 2,400 VA √
2400 VA x 125%	= 3,000 VA •
Total load	= 281,625 VA *

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**

82 receptacles x 180 VA	= 14,760 VA
160 ft x 180 VA	= 28,800 VA
Total load	= 43,560 VA
Table 220.44	
First 10,000 VA x 100%	= 10,000 VA
Next 33,560 VA x 50%	= 16,780 VA
Total load	= 26,780 VA • √

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**

30 receptacles x 180 VA	= 5,400 VA √
5400 VA x 125%	= 6,750 VA •
Total load	= 33,530 VA *

Calculating special load

Step 1: Water heater load
220.14(A)
18,000 VA x 100% = 18,000 VA • *

Calculating compressor load

Step 1: Freezer load
220.14(C), 220.50, and **230.42(A)(1)**
8640 VA x 100% = 8,640 VA •

Step 2: Ice cream box load
220.14(C), 220.50, and **230.42(A)(1)**
5820 VA x 100% = 5,820 VA •

Step 3: Walk-in cooler
220.14(C), 220.50, and **230.42(A)(1)**

9680 VA x 100%	= 9,680 VA •
Total load	= 24,140 VA *

Calculating motor load

Step 1: Water pump load
220.14(C), 220.50, 430.24 and **Table 430.250**
6.8 A x 416 V x 100% = 2,829 VA •

Step 2: Exhaust fan load
220.14(C), 220.50, 430.24 and **Table 430.250**

3.2 A x 416 V x 100%	= 1,331 VA •
Total load	= 4,160 VA *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
50,000 VA x 100% = 50,000 VA • *

Calculating largest motor load

Step 1: Walk.in cooler load
220.14(C), 220.50, and **430.24**
9680 VA x 25% = 2,420 VA • *

Single-phase loads
[add single-phase loads (•)]

Lighting loads	= 281,625 VA •
Receptacle loads	= 33,530 VA •
Total load	= 315,155 VA

Three-phase loads
[add three-phse loads (•)]

Special loads	= 18,000 VA •
Compressor loads	= 24,140 VA •
Motor loads	= 4,160 VA •
Heating load	= 50,000 VA •
Largest motor load	= 2,420 VA •
Total Load	= 98,720 VA

Calculating grounded (neutral) conductors

[add neutral load (√)]

Lighting loads	= 231,900 VA √
Receptacle loads	= 32,180 VA √
Total load	= 264,080 VA

Finding single-phase load

I = VA ÷ V
I = 315,155 VA ÷ 240 V
I = 1313 A

Finding three-phase load

I = VA ÷ V
I = 98,720 VA ÷ 416 V
I = 237 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 264,080 VA ÷ 240 V
I = 1100 A

Finding amps for ungrounded (phase) conductors - Phases A, B, and C

Single-phase load	= 1,313 A
Three-phase load	= 237 A
Total load	= 1,550 A

Finding amps for the ungrounded (phase) conductor - Phase B

Three-phase load	= 237 A

103. Calculating load in VA and amps for a office building including meeting hall - standard calculation (277/480 volt, three.phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**

130,000 sq. ft x 3.5 VA	= 455,000 VA √
455,000 VA x 125%	= 568,750 VA •
5000 sq. ft x 1/2 VA	= 2,500 VA √
2500 VA x 125%	= 3,125 VA •

Step 2: Track lighting load
220.43(B) and **410.151(B)**

100 ft ÷ 2 ft x 150 VA	= 7,500 VA • √

Step 3: Low-voltage lighting load
220.14(D), Article 411, and **230.42(A)(2)**

8000 VA x 100%	= 8,000 VA √
8000 VA x 125%	= 10,000 VA •

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**

30 ballasts x 180 VA	= 5,400 VA √
5400 VA x 125%	= 6,750 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**

3800 VA x 100%	= 3,800 VA √
3800 VA x 125%	= 4,750 VA •
Total load	= 600,875 VA *

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**

152 receptacles x 180 VA	= 27,360 VA
200 ft x 180 VA	= 36,000 VA
Total load	= 63,360 VA
Table 220.44	
130,000 x 1 VA	= 130,000 VA
Total load	= 130,000 VA •

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**

138 receptacles x 180 VA	= 24,840 VA
24,840 VA x 125%	= 31,050 VA •
Total load	= 67,730 VA *

Calculating special load

Step 1: Water heater load
220.14(A), 422.13, and **230.42(A)(1)**

10,000 VA x 100%	= 10,000 VA •

Step 2: Copying machine load
220.14(A) and **230.42(A)(2)**

1480 VA x 2	= 2,960 VA
2960 VA x 125%	= 3,700 VA •

Step 3: Data processor load
220.14(A) and **230.42(A)(2)**

225 VA x 34	= 7,650 VA
7650 VA x 125%	= 9,563 VA •

Step 4: Word processor load
220.14(A) and **230.42(A)(2)**

175 VA x 10	= 1,750 VA
1750 VA x 125%	= 2,188 VA •

Step 5: Printer load
220.14(A) and **230.42(A)(2)**

1200 VA x 4	= 4,800 VA
4800 VA x 125%	= 6,000 VA •
Total load	= 31,451 VA *

Calculating motor load

Step 1: 50 HP elevator
430.24, 430.22(E), Table 430.22(E), and **Table 620.14**

65 A x 831 V x 85%	= 45,913 VA • *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**

30,000 VA x 100%	= 30,000 VA • *

Calculating largest motor load

Step 1: Elevator load
220.14 and **430.24**

45,913 VA x 25%	= 11,478 VA • *
Total load of facility (add dots)	= 880,767 VA

Calculating grounded (neutral) conductors [add neutral loads (√)]

General lighting load	
(office)	= 455,000 VA √
(halls)	= 2,500 VA √
Track lighting load	= 7,500 VA √
Low-voltage lighting load	= 8,000 VA √
Outside lighting load	= 5,400 VA √
Sign lighting load	= 3,800 VA √
Total load	= 482,200 VA

Finding amps for ungrounded (phase) conductors – Phases A, B, and C

I = VA ÷ V
I = 880,767 VA ÷ 831 V
I = 1,060 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 482,200 VA ÷ 831 V
I = 580 A

(A) Finding ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ number in parallel
A = 1060 A ÷ 4
A = 265

Step 2: Selecting conductor size
Table 310.16
265 A requires 300 KCMIL THWN
300 KCMIL = 285 A

Solution: It takes 4 – 300 KCMIL THWN copper conductors to supply a load of 948 amps (285 A x 4 = 1140 A).

(B) Finding overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(C), and **240.6(A)**
1060 A requires 1000 A OCPD

Solution: The size overcurrent protection device based on calculated load is 1000 amps.

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ number in parallel
A = 580 A ÷ 4
A = 145

Step 2: Selecting conductor size
Table 310.16
145 A requires 1/0 AWG cu.
1/0 AWG cu. = 150 A

Solution: It takes 4 – 1/0 AWG THWN copper conductors to supply a load of 580 amps (150 A x 4 = 600 A).

(D) Sizing rigid metal conduit for each run

Step 1: Sizing sq. in. area
Table 5, Ch. 9
300 KCMIL = .4608 sq. in.
1/0 THWN = .1855 sq. in.

Step 2: Calculating total sq. in. area
Table 5, Ch. 9

.4608 sq. in. x 3	= 1.3824 sq. in.
.1855 sq. in. x 1	= .1855 sq. in.
Total sq. in.	= 1.5679 sq. in.

Step 3: Selecting rigid metal conduit
Table 4, Ch. 9
1.5679 sq. in. requires 2-1/2" (63)

Solution: The size rigid metal conduit for each run is 2-1/2 in. (63).

104. Calculating load in VA and amps for a school building - standard calculation (277/480 volt, three-phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**

40,000 sq. ft x 3 VA	= 120,000 VA √
120,000 VA x 125%	= 150,000 VA •
8000 sq. ft x 1 VA	= 8,000 VA √
8000 VA x 125%	= 10,000 VA •
1500 sq. ft x 1 VA	= 1,500 VA √
1500 VA x 125%	= 1,875 VA •
Total load	= 161,875 VA *

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**

190 receptacles x 180 VA	= 34,200 VA
200 ft x 180 VA	= 36,000 VA
Total load	= 70,200 VA
Table 220.44	
First 10,000 VA x 100%	= 10,000 VA
Next 60,200 VA x 50%	= 30,100 VA
Total load	= 40,100 VA •

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**

60 receptacles x 180 VA	= 10,800 VA
10,800 VA x 125%	= 13,500 VA •
Total load	= 53,600 VA *

Calculating special load

Step 1: Kitchen equipment
220.56
Toasters

	2 x 1.2 kW x 1000	= 2,400 VA
	Refrigerators	
	6 x 1.4 kW x 1000	= 8,400 VA
	Freezers	
	4 x 1.6 kW x 1000	= 6,400 VA
	Ranges	
	6 x 12 kW x 1000	= 72,000 VA
	Ovens	
	4 x 9 kW x 1000	= 36,000 VA
	Fryers	
	4 x 4 kW x 1000	= 16,000 VA
	Total load	= 141,200 VA
Step 2:	Applying demand factors	
	Table 220.56	
	141,200 VA x 65%	= 91,780 VA • *

Calculating motor load

Step 1:	Exhaust fans	
	Table 430.250 and **220.50**	
	32 A x 100% x 480 V	= 15,360 VA
	15,360 VA x 1.732	= 26,604 VA •
	(1.6 A x 20 = 32 A)	
Step 2:	Hood fans	
	Table 430.248 and **220.50**	
	52.8 A x 100% x 208 V	= 10,982 VA •
	(13.2 A x 4 = 52.8 A)	
Step 3:	Grill vent fans	
	Table 430.248 and **220.50**	
	21.6 A x 100% x 208 V	= 4,493 VA •
	(5.4 A x 4 = 21.6 A)	
	Total load	= 42,079 VA *

Calculating largest motor load

Step 1:	Hood fan load	
	220.14(C), 220.50, and **430.24**	
	13.2 A x 100% x 208 V	= 2,746 VA
	2746 VA x 25%	= 687 VA • *
	Total load of facility (add all dots)	= 350,021 VA •

Calculating grounded (neutral) conductors [add neutral loads (√)]

Lighting load = 129,500 VA √

Finding amps for ungrounded (phase) conductors – Phases A, B, and C

I = VA ÷ V
I = 350,021 VA ÷ 831 V
I = 421 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 129,500 VA ÷ 831 V
I = 156 A

(A) Finding ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ number in parallel
A = 421 A ÷ 2
A = 211

Step 2: Selecting conductor size
Table 310.16
211 A requires 4/0 AWG THWN
4/0 AWG THWN = 230 A

Solution: It takes 2 – 4/0 AWG THWN copper conductors to supply a load of 421 amps (230 A x 2 = 460 A).

(B) Finding overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(B), and **240.6(A)**
421 A requires 450 A OCPD

Solution: The size overcurrent protection device based on calculated load is 450 amps.

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4 and **250.24(C)(2)**
Amps of conductors = service amps ÷ # in parallel
A = 156 A ÷ 2
A = 78

Step 2: Selecting conductor size
Table 310.16
78 A requires 1/0 AWG cu.
1/0 AWG cu. = 150 A

Solution: It takes 2 – 1/0 AWG THWN copper conductors to supply a load of 156 amps (150 A x 2 = 300 A).

(D) Sizing rigid metal conduit for each run

Step 1:	Sizing sq. in. area	
	Table 5, Ch. 9	
	4/0 AWG THWN = .3237 sq. in.	
	1/0 AWG THWN = .1855 sq. in.	
Step 2:	Calculating total sq. in. area	
	Table 5, Ch. 9	
	.3237 sq. in. x 3	= .9711 sq. in.
	.1855 sq. in. x 1	= .1855 sq. in.
	Total sq. in.	= 1.1566 sq. in.

Step 3: Selecting rigid metal conduit
Table 4, Ch. 9
1.1566 sq. in. requires 2" (53)

Solution: The size rigid metal conduit for each run is 2 in. (53).

105. Calculating load in VA and amps for a restaurant - standard calculation (120/208 volt, three.phase service)

Calculating lighting load

Step 1: General lighting load

Table 220.12 and **230.42(A)(2)**
8000 sq. ft x 2 VA = 16,000 VA √
16,000 VA x 125% = 20,000 VA •

Step 2: Track lighting load
220.43(B) and **410.151(B)**
40 ft ÷ 2 ft x 150 VA = 3,000 VA √
3000 VA x 125% = 3,750 VA •

Step 3: Outside lighting load
220.14(D) and **230.42(A)(2)**
14 ballasts x 180 VA = 2,520 VA √
2520 VA x 125% = 3,150 VA •

Step 4: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**
2400 VA x 100% = 2,400 VA √
2400 VA x 125% = 3,000 VA •
Total load = 29,900 VA *

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**
50 receptacles x 180 VA = 9,000 VA
60 ft x 180 VA = 10,800 VA
Total load = 19,800 VA
Table 220.44
First 10,000 VA x 100% = 10,000 VA
Next 9800 VA x 50% = 4,900 VA
Total load = 14,900 VA • √

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**
20 receptacles x 180 VA = 3,600 VA √
3600 VA x 125% = 4,500 VA •
Total load = 19,400 VA *

Calculating special load

Step 1: Kitchen equipment
220.56
Freezer (15 A x 208 V) = 3,120 VA
Cooktop = 12,000 VA
Ovens (10,000 VA x 2) = 20,000 VA
Range = 12,000 VA
Refrigerator (18 A x 208 V) = 3,744 VA
Ice cream box = 4,250 VA
Boiler = 4,400 VA
Deep fat fryers (3200 VA x 2) = 6,400 VA
Walk-in cooler (20 A x 360 V) = 7,200 VA
Water heater = 6,000 VA
Total load = 79,114 VA

Step 2: Applying demand factors
Table 220.56
79,114 VA x 65% = 51,424 VA • *

Calculating motor loads

Step 1: Hood fan
430.22(A), 430.24, 430.25, and **220.50**
6450 VA x 100% = 6,450 VA •

Step 2: Grill vent fan
430.22(A), 430.24, 430.25, and **220.50**
5245 VA x 100% = 5,245 VA •
Total load = 11,695 VA *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
30 kW x 2 x 1000 = 60,000 VA • *

Calculating largest motor load

Step 1: Walk-in cooler load
220.50 and **430.24**
20 A x 100% x 360 V = 7,200 VA
7200 VA x 25% = 1,800 VA • *
Total load of facility (add all dots) = 174,219 VA •

Calculating grounded (neutral) conductor [add neutral loads (√)]

Lighting load = 23,920 VA √
Receptacle load = 18,500 VA √
Total load = 42,420 VA
√

Finding amps for ungrounded (phase) conductors – Phases A, B, and C

I = VA ÷ V
I = 174,219 VA ÷ 360 V
I = 484 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V
I = 42,420 VA ÷ 360 V
I = 118 A

(A) Finding ungrounded (phase) conductors

Step 1: Paralleling conductors
310.4
Amps of conductors = service amps ÷ number in parallel
A = 484 A ÷ 2
A = 242
Step 2: Selecting conductor size
Table 310.16
242 A requires 250 KCMIL THWN
250 KCMIL = 255 A

Solution: **It takes 2 – 250 KCMIL THWN copper conductors to supply a load of 484 amps (255 A x 2 = 510 A).**

(B) Finding overcurrent protection device for service

Step 1: Sizing OCPD
230.90(A), 240.4(B), and **240.6(A)**
484 A requires 500 A OCPD

Solution: **The size overcurrent protection device based on calculated load is 500 amps.**

(C) Finding size grounded (neutral) conductor

Step 1: Selecting conductor size
310.4
Amps of conductors = service amps ÷ # in parallel
A = 118 A ÷ 2
A = 59

Step 2: Selecting conductor size
Table 310.16 and **250.24(C)(2)**
59 A requires 1/0 AWG cu.
1/0 AWG cu. = 150 A

Solution: **It takes 2 – 1/0 AWG THWN copper conductors to supply a load of 116 amps (150 A x 2 = 300 A).**

(D) Sizing rigid metal conduit for each run

Step 1: Sizing sq. in. area
Table 5, Ch. 9
250 KCMIL = .397 sq. in.
1/0 AWG THWN = .1855 sq. in.

Step 2: Calculating total sq. in. area
Table 5, Ch. 9
.3970 sq. in. x 3 = 1.191 sq. in.
.1855 sq. in. x 1 = .1855 sq. in.
Total sq. in. = 1.3765 sq. in.

Step 3: Selecting rigid metal conduit
Table 4, Ch. 9
1.3765 sq. in. requires 2-1/2" (63)

Solution: **The size rigid metal conduit for each run is 2-1/2 in. (63).**

106. Calculating load in VA and amps for a hospital . standard calculation (277/480 volt, three.phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12, 230.42(A)(2), and **Table 220.42**
52,000 sq. ft x 2 VA = 104,000 VA
First 50,000 VA x 40% = 20,000 VA
Next 54,000 VA x 20% = 10,800 VA
Total load = 30,800 VA • √

Step 2: Show window load
220.43(A) and **220.14(G)**
60 ft x 200 VA = 12,000 VA •

Step 3: Track lighting load
220.43(B) and **410.151(B)**
100 ft ÷ 2 ft x 150 VA = 7,500 VA •

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**
28 ballasts x 225 VA = 6,300 VA
6300 VA x 125% = 7,875 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**
4 x 3600 VA = 14,400 VA
14,400 VA x 125% = 18,000 VA •
Total load = 76,175 VA

*

Calculating receptacle load

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(1)**
228 receptacles x 180 VA = 41,040 VA
200 ft x 180 VA = 36,000 VA
Total load = 77,040 VA
Table 220.44
First 10,000 VA x 100% = 10,000 VA
Next 67,040 VA x 50% = 33,520 VA
Total load = 43,520 VA •

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**
96 receptacles x 180 VA = 17,280 VA
17,280 VA x 125% = 21,600 VA •
Total load = 65,120 VA

*

Calculating special loads

Step 1: Copying machine load
220.14(A) and **230.42(A)(2)**
1000 VA x 7 = 7,000 VA
7000 VA x 125% = 8,750 VA

•

Step 2: Soft drink machine load
220.14(A) and **230.42(A)(2)**
1400 VA x 4 = 5,600 VA
5600 VA x 125% = 7,000 VA •

Step 3: X-ray equipment (momentary rating)
517.73(A)(2) (to calculate, see page 11-46)
200 ma ÷ 1000 x 50% x 1000,000 V = 7,500 VA •

Step 4: X-ray equipment (momentary rating)
517.73(A)(2) (to calculate, see page 11-46)
second largest X-ray equipment
200 ma ÷ 1000 x 25% x 1000,000 V = 3,250 VA •

Step 5: Emergency system (life safety)
230.42(A)(1) and **517.30(D)**
50,000 VA x 100% = 50,000 VA •

Step 6: Emergency system (critical)
230.42(A)(1) and **517.30(D)**
50,000 VA x 100% = 50,000 VA •
Total load = 137,299 VA *

Calculating motor loads

Step 1: Water pump load
Table 430.250 and **430.24**
5420 VA x 4 = 21,680 VA •

Step 2: Exhaust fan load
Table 430.250 and **430.24**
4.8 A x 8 x 831 V = 31,910 VA •

Step 3: Sprinkler pump load
Table 430.250 and **430.24**
11 A x 831 V = 9,141 VA •
Total load = 62,731 VA

*

Calculating heating and air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
35,000 VA x 6 units x 100% = 210,000 VA • *

Calculating largest motor load

Step 1: Sprinkler pump load selected
220.50 and **430.24**
9141 VA x 25% = 2,285 VA • *
Total load of facility (add all dots) = 543,311 VA •

Calculating grounded (neutral) conductors [add neutral loads (√)]

General lighting load = 30,800 VA √

Finding amps for ungrounded (phase) conductors – Phases A, B, and C

I = VA ÷ V x √3
I = 543,311 VA ÷ 831 V
I = 654 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V x √3
I = 30,800 VA ÷ 831 V
I = 37 A

(A) Finding general lighting load

Step 1: Finding VA
Table 220.12
52,000 sq. ft x 2 VA = 104,000 VA

Step 2: Applying demand factors
Table 220.42
First 50,000 VA x 40% = 20,000 VA
Next 54,000 VA x 20% = 10,800 VA
Total load = 30,800 VA

Solution: The general lighting load is 30,800 VA.

—

(B) Finding branch-circuit load for X-ray equipment

Step 1: Finding amperage
A = (MA ÷ 1000) x (Sec. V ÷ Pri. V)
A = (200 MA ÷ 1000) x (100,000 ÷ 208 V)
A = 96

Step 2: Applying demand factor
660.6(A)
96 A x 50% = 48 A

Solution: The amperage is 48 amps.

(C) Finding THWN copper conductors for X-ray equipment

Step 1: Selecting conductors
Table 310.16
48 A requires 8 AWG cu.

Solution: The size THWN conductors are 8 AWG copper.

(D) Finding branch-circuit load for X-ray equipment

Step 1: Finding amperage
A = (MA ÷ 1000) x (Sec. V ÷ Pri. V)
A = (20 MA ÷ 1000) x (200,000 ÷ 208 V)
A = 19

Step 2: Applying demand factor
660.6(A)
19 A x 100% = 19 A

Solution: The amperage is 19 amps.

(E) Finding THWN copper conductors for X-ray equipment

Step 1: Selecting conductors
Table 310.16
19 A requires 14 AWG cu.

Solution: The size THWN conductors are 14 AWG copper.

(F) Finding total VA and amps for X-ray equipment

Step 1: Finding amperage – short-time ratings
A = (MA ÷ 1000) x (Sec. V ÷ Pri. V)
A = (200 MA ÷ 1000) x (100,000 ÷ 208 V)
A = 96

Step 2: Finding amperage - long-time ratings
A = (MA ÷ 1000) x (Sec. V ÷ Pri. V)
A = (20 MA ÷ 1000) x (200,000 ÷ 208 V)
A = 19

Step 3: Finding VA
660.6(B)
Short-time rating
96 A x 2 x 50% x 208 V x 100% = 19,968 VA
Long-time rating
19 A x 2 x 208 V = 7,904 VA
7904 VA x 20% = 1,581 VA

Step 4: Finding total VA
660.6(B)
Short-time rating = 19,968 VA
Long-time rating = 1,581 VA
Total load = 21,549 VA

Step 5: Finding amperage
Text
I = VA ÷ V
I = 21,549 VA ÷ 208 V
I = 103.6 A

Solution: The amperage is 103.6 amps.

(G) Finding size THWN copper conductors for X-ray equipment

Step 1: Selecting size conductors
Table 310.16
103.6 A requires 2 AWG cu.

Solution: The size THWN conductors are 2 AWG copper.

107. Calculating load in VA and amps for a hotel - standard calculation (120/208 volt, three-phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12
410 sq. ft x 2 VA x 40 units = 32,800 VA
Applying demand factors
Table 220.44
First 20,000 VA x 50% = 10,000 VA
Next 12,800 VA x 40% = 5,120 VA
Total load = 15,120 VA • √

Step 2: Show window load
220.43(A) and **220.14(G)(2)**
40 ft x 200 VA = 8,000 VA • √

Step 3: Track lighting load
220.43(B) and **410.151(B)**
50 ft ÷ 2 ft x 150 VA = 3,750 VA • √

Step 4: Outside lighting load
220.14(D) and **230.42(A)(2)**
22 ballasts x 275 VA = 6,050 VA √
6050 VA x 125% = 7,563 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**
1800 VA x 4 x 100% = 7,200 VA √
7200 VA x 125% = 9,000 VA •
Total load = 43,433 VA *

Calculating receptacle loads

Step 1: Continuous operation
220.14(I) and **230.42(A)(2)**
74 receptacles x 180 VA = 13,320 VA √
13,320 VA x 125% = 16,650 VA • *

Calculating special loads

Step 1: Copying machine load
220.14(A) and **230.42(A)(2)**
4 units x 1000 VA = 4,000 VA √
4000 VA x 125% = 5,000 VA •

Step 2: Soft drink machine load
220.14(A) and **230.42(A)(2)**
8 units x 1400 VA = 11,200 VA √
11,200 VA x 125% = 14,000 VA •

Step 3: House loads
220.14(A) and **230.42(A)(2)**
7200 VA x 100% = 7,200 VA √
7200 VA x 125% = 9,000 VA •
28,200 VA x 100% = 28,200 VA
28,200 VA x 125% = 35,250 VA •

Step 4: Exhaust fan load
220.50, 230.42(A)(1), Table 430.248, and **430.24**
40 units x 5.8 A x 120 V = 27,840 VA • √

Step 5: Water heater load
220.14(A) and **230.42(A)(1)**
6 units x 8500 VA x 100% = 51,000 VA •

Step 6: Laundry facility load
230.42(A)(2)
18,420 VA x 100% = 18,420 VA
18,420 VA x 125% = 23,025 VA •
Total load = 165,115 VA *

Calculating heating or air-conditioning load

Step 1: Heating loads selected
220.60 and **220.51**
2 units x 20,000 VA x 100% = 40,000 VA •
8712 VA x 40 units x 100% = 348,480 VA •
Total load = 388,480 VA *

Calculating largest motor load

Step 1: Heat pump and soft drink selected
8712 x 25% (**220.50**) = 2,178 VA •
1400 VA x 25% (**220.50**) = 350 VA √
Total load of facility (add all dots) = 615,856 VA

Calculating grounded (neutral) conductors [add neutral loads (√)]

Lighting loads = 40,120 VA √
Receptacle loads = 13,320 VA √
Special loads = 50,240 VA √
Largest motor load = 0 VA
Total load = 103,680 VA

Finding amps for (ungrounded) phase conductors – Phases A, B, and C

I = VA ÷ V x √3
I = 615,856 VA ÷ 360 V
I = 1711 A

Finding amps for grounded (neutral) conductor

I = VA ÷ V x √3
I = 103,680 VA ÷ 360 V
I = 288 A

108. Calculating load in VA and amps for a bank-standard calculation (120/208 volt, three-phase service)

Calculating lighting load

Step 1: General lighting load
Table 220.12 and **230.42(A)(2)**
7400 sq. ft x 3.5 = 25,900 VA √
25,900 VA x 125% = 32,375 VA •
—

Step 2: Show window load
220.14(C) and **220.43(A)**
60 ft x 200 VA = 12,000 VA • √

Step 3: Track lighting load
220.43(B) and **410.151(B)**
80 ft ÷ 2 ft x 150 VA = 6,000 VA • √

Step 4: Outside lighting load
230.42(A)(2)
30 ballasts x 180 VA = 5,400 VA √
5400 VA x 125% = 6,750 VA •

Step 5: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**
1800 VA x 100% = 1,800 VA √
1800 VA x 125% = 2,250 VA •
Total load = 59,375 VA *

Calculating receptacle loads

Step 1: Noncontinuous operation
220.14(I), 220.14(H)(1) and **(H)(2),** and **230.42(A)(2)**
88 receptacles x 180 VA = 15,840 VA
40 ft x 180 VA = 7,200 VA
Total load = 23,040 VA
7400 sq. ft x 1 VA = 7,400 VA
First 10,000 VA x 100% = 10,000 VA
First 13,040 VA x 50% = 6,520 VA
Total load = 16,520 VA • √

Step 2: Continuous operation
220.14(I) and **230.42(A)(2)**
45 receptacles x 180 VA = 8,100 VA √
8100 VA x 125% = 10,125 VA •
Total load = 26,645 VA *

Calculating special loads

Step 1: Miscellaneous loads
230.43(A)(2)
6420 VA x 100% = 6,420 VA √
6420 VA x 125% = 8,025 VA •
18,420 VA x 100% = 18,420 VA
18,420 VA x 125% = 23,025 VA •

Step 2: Personal computers
230.42(A)(2)
22 x 1600 VA = 35,200 VA √
35,200 VA x 125% = 44,000 VA •

Step 3: Water heater load
220.14(A) and **230.42(A)(1)**
8000 VA x 100% = 8,000 VA •

Step 4: Range load
220.14(A) and **230.42(A)(1)**
14,000 VA x 100% = 14,000 VA •
Total load = 97,050 VA *

Calculating motor loads

Step 1: Fans load
430.24 and **Table 430.248**
18 x 5.8 A x 120 V = 12,528 VA • √

Step 2: Pump motors load
430.24 and **Table 430.250**
3 x 16.7 A x 360 V = 18,036 VA •

Step 3: Exhaust fans load
430.24 and **Table 430.250**
10 x 7.5 A x 360 V = 27,000 VA •
Total load = 57,564 VA *

Calculating heating or air-conditioning load

Step 1: Heating load selected
220.60 and **220.51**
25,000 VA x 100% = 25,000 VA • *

Calculating largest motor load

Step 1: Pump motor and fan load selected
220.50, 430.24, and **210.19(A)(1), Ex. 2**
16.7 A x 360 V x 25% = 1,503 VA •
5.8 A x 120 V = 0 VA
Total load of facility (add all dots) = 267,137 VA •

Calculating grounded (neutral) conductors [add neutral loads (√)]

Lighting loads = 51,100 VA √
Receptacle loads = 24,620 VA √
Special loads = 41,620 VA √
Motor loads = 12,528 VA √
Largest motor load = 0 VA
Total load = 129,868 VA

Finding amps for ungrounded (phase) conductors – Phases A, B, and C

I = VA ÷ V x √3
I = 267,137 VA ÷ 360 V
I = 742 A

Finding amps for grounded (neutral) conductors

I = VA ÷ V x √3
I = 129,868 VA ÷ 360 V
I = 361 A

109. Calculating load in VA and amps for a welding shop - standard calculation (120/208 volt, three-phase service)

Calculating lighting loads

Step 1: Inside lighting load
230.42(A)(2)
8400 VA x 100% = 8,400 VA √
8400 VA x 125% = 10,500 VA •

Step 2: Outside lighting load
230.42(A)(2)
4 ballasts x 180 VA = 720 VA √
720 VA x 125% = 900 VA •

Step 3: Sign lighting load
220.14(F), 600.5(A), and **230.42(A)(2)**
1200 VA x 100% = 1,200 VA √

	1200 VA x 125%	= 1,500 VA •
	Total load	= 12,900 VA *

Calculating receptacle load

Step 1:	Continuous operation	
	220.14(I) and **230.42(A)(2)**	
	50 receptacles x 180 VA	= 9,000 VA √
	9000 VA x 125%	= 11,250 VA • *

Calculating special loads

Step 1:	Welders – resistance	
	630.31(A) and **(B)**	
	11,000 VA x 63%	= 6,930 VA •
	9000 VA x 63% x 60%	= 3,402 VA •
Step 2:	Welders – arc welder with motor	
	630.11(A) and **(B)**	
	16,000 VA x 91%	= 14,560 VA •
	13,000 VA x 91%	= 11,830 VA •
Step 3:	Welders – arc welder without motor	
	630.11(A) and **(B)**	
	14,000 VA x 84%	= 11,760 VA •
	8000 VA x 84%	= 6,720 VA •
	Total load	= 55,202 VA *

Calculating compressor and motor loads

Step 1:	Air.compressor load	
	430.24 and **Table 430.248**	
	16.7 A x 100% x 360 V	= 6,012 VA •
Step 2:	Grinders	
	430.24 and **Table 430.248**	
	7.5 A x 2 x 360 V	= 5,400 VA •
	Total loads	= 11,412 VA *

Calculating heating or air-conditioning load

Step 1:	Heating load	
	220.60 and **220.51**	
	10,000 VA x 2 units x 100%	= 20,000 VA • *

Calculating largest motor load

Step 1:	Air compressor load	
	220.50 and **430.24**	
	16.7 A x 360 V x 25%	= 1,503 VA • *

Calculating ungrounded (phase) conductors [adding dots (•)]

Lighting loads	= 12,900 VA •
Receptacle loads	= 11,250 VA •
Special loads	= 55,202 VA •
Motor loads	= 11,412 VA •
Heating load	= 20,000 VA •
Largest motor load	= 1,503 VA •
Total load	= 112,267 VA

Calculating grounded (neutral) conductors [adding neutral loads (V)]

Lighting loads	= 10,320 VA √
Receptacle loads	= 9,000 VA √
Total load	= 19,320 VA

Finding amps for ungrounded (phase) conductors - Phases A, B, and C

I = VA ÷ V x √3
I = 112,267 VA ÷ 360 V
I = 312 A

Finding amps for grounded (neutral) conductors

= VA ÷ V x √3
I = 19,320 VA ÷ 360 V
I = 54 A

110. Calculating load in VA for a school building - optional calculation (277/480 volt, three-phase service)

Step 1:	Calculating sq. ft	
	Classroom area	= 40,000 sq. ft
	Auditorium area	= 5,000 sq. ft
	Cafeteria area	= 5,000 sq. ft
	Hall area	= 1,200 sq. ft
	Total area	= 51,200 sq. ft
Step 2:	Calculating VA per sq. ft	
	Table 220.86	
	VA per sq. ft = total VA ÷ total sq. ft	
	VA per sq. ft = 845,794 VA ÷ 51,200 sq. ft	
	VA per sq. ft = 16.519414	
Step 3:	Applying demand factors	
	Table 220.86	
	First 3 VA x sq. ft x 100%	
	Next 13.519414 x 75%	
	3 VA x 51,200 sq. ft x 100%	= 153,600 VA
	13.519414 x 51,200 sq. ft x 75%	= 519,145.49 VA
	Total load	= 672,745.49 VA

Solution: **The demand load in VA for the school is 672,745.49 VA.**

111. Calculating load in VA for a restaurant - optional calculation (120/208 volt, three-phase service)

Step 1:	Calculating total VA	
	220.88	
	Lighting loads	= 18,240 VA
	Receptacle loads	= 16,400 VA
	Special loads	= 98,215 VA
	Heating or A/C loads	= 40,000 VA
	Motor loads	= 7,200 VA
	Total load	= 180,055 VA
Step 2:	Applying demand factors	
	Table 220.88	
	Demand load = VA x demand factors	
	Demand load = 180,055 VA x 80%	
	Demand load = 144,044 VA	

Solution: **The demand load in VA for the restaurant is 144,044 VA.**

112. Adding load to existing service

Step 1: Finding demand
220.87
Maximum demand = 204 A

Step 2: Calculating existing demand
220.87
204 A x 125% = 255 A

Step 3: Calculating total amps
230.42(A)(1)
255 A + 125 A = 380 A

Step 4: Calculating amperage
Table 310.16
500 KCMIL THWN copper = 380 A
380 A is equal to 380 A

Solution: Yes, the 125 amps load can be added to the existing service.

Article 230
Services

113. Service conductors

Step 1: Calculating load
230.42(A)(1) and **(A)(2)**

92 A x 125%	= 115 A
84 A x 100%	= 84 A
Total load	= 199 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
199 A requires 3/0 AWG cu.

Solution: The size conductors are 3/0 AWG THWN copper.

114. Maximum setting for circuit breaker

Step 1: Selecting percentage
230.208
CB = 6 times (600%)

Step 2: Calculating OCPD setting
230.208
200 A x 6 = 1200 A

Solution: The maximum setting for the circuit breaker is 1200 amps.

115. Maximum rating for fuses

Step 1: Selecting percentages
230.208
Fuses = 3 times (300%)

Step 2: Calculating rating
230.208
200 A x 3 = 600 A

Solution: The rating of each fuse is 600 amps.

Article 240
Overcurrent Protection

116. Taps 10 ft (3 m) or less in length

Step 1: Calculating minimum size tap
240.21(B)(1)(4)
A = 300 A OCPD ÷ 10
A = 30

Step 2: Sizing conductors by 10 times
Table 310.16
10 AWG THWN cu. = 35 A
35 A x 10 = 350 A

Step 3: Verifying size
240.21(B)(1)(4)
350 A is greater than 300 A

Solution: The size conductors are 10 AWG THWN copper.

117. Taps 10 ft (3 m) or less in length

Step 1: Calculating minimum size tap
240.21(B)(1)(4)
A = 400 A OCPD ÷ 10
A = 40

Step 2: Sizing conductors by 10 times
Table 310.16
8 AWG THWN cu. = 50 A
50 A x 10 = 500 A

Step 3: Verifying size
240.21(B)(1)(4)
500 A is greater than 400 A

Solution: The size conductors are 8 AWG THWN copper.

118. Taps over 10 ft (3 m) to 25 ft (7.5 m) in length

Step 1: Calculating minimum size tap
240.21(B)(2)(1)
1/3 x 300 A OCPD = 100 A

Step 2: Selecting conductors
Table 310.16
100 A requires 3 AWG cu.

Solution: The size conductors are 3 AWG THWN copper.

119. Taps over 10 ft (3 m) to 25 ft (7.5 m) in length

Step 1: Calculating minimum size tap
240.21(B)(2)(1)
1/3 x 400 A OCPD = 133.3 A

Step 2: Selecting conductors
Table 310.16

133.3 A requires 1/0 AWG cu.

Solution: **The size conductors are 1/0 AWG THWN copper.**

120. Taps including transformer

Step 1: Calculating primary tap
240.21(B)(3)(1)
1/3 x 300 A OCPD = 100 A

Step 2: Selecting conductors
Table 310.16
100 A requires 3 AWG cu.

Step 3: Calculating secondary tap
240.21(B)(3)(1)
A = 480 V ÷ 208 V x 1/3 x 300 A
A = 231

Step 4: Selecting conductors
Table 310.16
231 A requires 250 KCMIL cu.

Solution: **The size conductors for the primary side are 3 AWG THWN copper and the size conductors for secondary side are 250 KCMIL THWN copper.**

121. Taps including transformer

Step 1: Calculating primary tap
240.21(B)(3)(1)
1/3 x 400 A OCPD = 133.3 A

Step 2: Selecting conductors
Table 310.16
133.3 A requires 1/0 AWG cu.

Step 3: Calculating secondary tap
240.21(B)(3)(1)
A = 480 V ÷ 208 V x 1/3 x 400 A
A = 308

Step 4: Selecting conductors
Table 310.16
308 A requires 350 KCMIL cu.

Solution: **The size conductors for the primary side are 1/0 AWG THWN copper and the size conductors for the secondary side are 350 KCMIL THWN copper.**

122. Taps over 25 ft (7.5 m) up to 100 ft (30 m) in length

Step 1: Calculating minimum size tap
240.21(B)(4)(3)
1/3 x 400 A OCPD = 133.3 A

Step 2: Selecting conductors
Table 310.16
133.3 A requires 1/0 AWG cu.

Solution: **The size conductors are 1/0 AWG THWN copper.**

123. Taps over 25 ft (7.5 m) up to 100 ft (30 m) in length

Step 1: Calculating minimum size tap
240.21(B)(4)(3)
1/3 x 600 A OCPD = 200 A

Step 2: Selecting conductors
Table 310.16
200 A requires 3/0 AWG cu.

Solution: **The size conductors are 3/0 AWG THWN copper.**

124. Busway taps

Step 1: Sizing tap
240.21(E) and **368.17 (B), Ex.**
450 A OCPD x 1/3 = 150 A

Step 2: Verifying size
150 A busway is equal to 150 A

Solution: **Yes, the 150 amp busway tap is equal to 150 amps, therefore, the tap complies with the *National Electrical Code®.***

125. Motor circuit taps

Step 1: Calculating minimum size tap
240.21(F) and **430.28(1)**
A = 400 A OCPD ÷ 10 (1000 ÷ 100)
A = 40

Step 2: Sizing conductors
Table 310.16
8 AWG THWN cu. = 50 A

Step 3: Verifying size
240.21(F) and **430.28(1)**
50 A is greater than 40 A

Solution: **The size conductors are 8 AWG THWN copper.**

126. Taps of 10 ft (3 m) from secondary of transformer

Step 1: Calculating FLA (secondary)
FLA = (150 kVA x 1000) ÷ (208 V x 1.732)
FLA = 416.6 A

Step 2: Sizing secondary OCPD
240.21(C)(2), 240.6(A), 450.3(B), and **Table 450.3(B)**
400 A secondary OCPD is less than the 416.6 A output

Solution: **The secondary overcurrent protection device rated at 400 amps protects the secondary conductors (416.6 A) and the 4 – 1/0 AWG parallel per phase (450 A) is equal to and greater than the output.**

127. Taps of 25 ft (7.5 m) from secondary of transformer

Step 1: Calculating FLA (secondary)
FLA = (150 kVA x 1000) ÷ (208 V x 1.732)
FLA = 416.6 A

Step 2: Sizing secondary OCPD
240.21(C)(3), 240.6(A), 450.3(B), and **Table 450.3(B)**
400 A secondary OCPD is less than the 416.6 A output

Solution: The secondary overcurrent protection device rated at 400 amps protects the secondary conductors (416.6 A) and the 4 – 1/0 AWG parallel per phase (450 A) is equal to and greater than the output.

Article 250
Grounding and Bonding

128. Sizing grounding electrode conductor to metal water pipe

Step 1: Calculating size grounding electrode conductor to water pipe
250.66, Table 250.66, 250.104(A), and **250.52(A)(1)**
350 KCMIL requires 2 AWG cu.

Solution: The size grounding electrode conductor is 2 AWG copper.

129. Sizing grounding electrode conductor to building steel

Step 1: Calculating size grounding electrode conductor to building steel
250.66, Table 250.66, 250.52(A)(2), and **250.104(C)**
350 KCMIL requires 2 AWG cu.

Solution: The size grounding electrode conductor is 2 AWG copper.

130. Sizing grounding electrode conductor to concrete-encased electrode

Step 1: Calculating size GEC to CEE
250.52(A)(3) and **250.66(B)**
350 KCMIL requires 4 AWG cu.

Solution: The size grounding electrode conductor is 4 AWG copper.

131. Sizing grounding electrode conductor to ground ring

Step 1: Calculating size GEC to ground ring
250.52(A)(4) and **250.66(C)**
350 KCMIL requires 2 AWG cu.

Solution: The size grounding electrode conductor is 2 AWG copper.

132. Sizing grounded service conductor

Step 1: Calculating minimum size grounded service conductor
250.24(C)(1) and **Table 250.66**
350 KCMIL cu. requires 2 AWG cu.

Solution: The size grounded service conductor is 2 AWG copper.

133. Sizing grounded service conductor

Step 1: Calculating grounded service conductor
250.24(C)(1) and **(C)(2)**
600 KCMIL x 3 per phase = 1800 KCMIL

Step 2: Calculating total KCMIL
250.24(C)(1) and **(C)(2)**
1800 KCMIL x .125 = 225 KCMIL

Step 3: Calculating KCMIL for each conduit
250.24(C)(2) and **310.4**
225 KCMIL ÷ 3 per phase = 75 KCMIL

Step 4: Calculating each conductor
250.24(C)(2) and **310.4**
75 KCMIL x 1000 = 75,000 CM

Step 5: Sizing each conductor
250.24(C)(2), 310.4, and **Table 8, Ch. 9**
75,000 CM requires 1/0 AWG cu.

Solution: Section 310.4 requires 1/0 AWG THHN copper conductors in each conduit.

134. Sizing grounding electrode conductor to building steel – separately derived system

Step 1: Calculating GEC for building steel
250.30(A)(7)(2), Table 250.66, and **250.52(A)(2)**
3/0 AWG cu. requires 4 AWG cu.

Solution: The size grounding electrode conductor is 4 AWG copper.

135. Sizing grounding electrode conductor to metal water pipe – separately derived system

Step 1: Calculating GEC for metal water pipe
250.30(A)(7)(1), Table 250.66, and 250.52(A)(1)
3/0 AWG cu. requires 4 AWG cu.

Solution: The size grounding electrode conductor is 4 AWG copper.

136. Sizing grounding electrode conductor to driven rod – separately derived system

Step 1: Calculating size GEC to driven rod
250.30(A)(7), Ex. 1 and **250.66(A)**
3/0 AWG cu. requires 6 AWG cu.

Solution: The size grounding electrode conductor is 6 AWG copper.

137. Sizing system bonding jumper – separately derived system

Step 1: Calculating sizes BJ
250.30(A)(1), 250.28(D), and **Table 250.66**
3/0 AWG cu. requires 4 AWG cu.

Solution: The sizes bonding jumper is 4 AWG copper.

138. Sizing equipment grounding conductor

Step 1: Calculating EGC
250.122(A) and **Table 250.122**
35 A OCPD requires 10 AWG cu.

Solution: The size equipment grounding conductor is 10 AWG copper.

139. Sizing equipment grounding conductor

Step 1: Calculating EGC
250.122(A) and **Table 250.122**

200 A OCPD requires 6 AWG cu.

Solution: The size equipment grounding conductor is 6 AWG copper.

140. Sizing equipment grounding conductor

Step 1: Calculating EGC
250.122(F) and **Table 250.122**
600 A OCPD requires 1 AWG cu.

Solution: The size equipment grounding conductor in each conduit is 1 AWG copper.

Article 310
Conductors for General Wiring

141. Applying adjustment factors

Step 1: Finding amperage of conductor
Table 310.16
12 AWG THHN cu. = 30 A

Step 2: Finding derating factors
Table 310.15(B)(2)(a)
14 conductors requires 50%

Step 3: Finding ampacity
Table 310.15(B)(2)(a)
30 A x 50% = 15 A

Solution: The ampacity is limited to 15 amps for each conductor.

142. Applying adjustment factors

Step 1: Finding amperage of conductor
Table 310.16
10 AWG THHN cu. = 40 A

Step 2: Finding derating factors
Table 310.15(B)(2)(a)
6 conductors requires 80%

Step 3: Finding ampacity
Table 310.15(B)(2)(a)
40 A x 80% = 32 A

Solution: The ampacity is limited to 32 amps for each conductor.

143. Applying adjustment factors

Step 1: Finding amperage of conductor
Table 310.16
10 AWG THHN cu. = 40 A

Step 2: Finding derating factors
Table 310.15(B)(2)(a)
12 conductors requires 50%

Step 3: Finding ampacity
Table 310.15(B)(2)(a)
40 A x 50% = 20 A

Solution: The ampacity is limited to 20 amps for each conductor.

144. Applying correction factors

Step 1: Finding amperage of conductors
Table 310.16
8 AWG THHN = 55 A

Step 2: Finding correction factors
Ampacity correction factors to **Table 310.16**
122°F requires 82%

Step 3: Finding ampacity
Ampacity correction factors to **Table 310.16**
55 A x 82% = 45.1 A

Solution: The ampacity is limited to 45.1 amps for each conductor.

145. Applying correction factors

Step 1: Finding amperage of conductors
Table 310.16
10 AWG THHN = 40 A

Step 2: Finding correction factors
Ampacity correction factors to **Table 310.16**
102°F requires 91%

Step 3: Finding ampacity
Ampacity correction factors to **Table 310.16**
40 A x 91% = 36.4 A

Solution: The ampacity is limited to 36.4 amps for each conductor.

146. Applying correction factors

Step 1: Finding amperage of conductors
Table 310.16
12 AWG THHN = 30 A

Step 2: Finding adjustment factor
Table 310.15(B)(2)(a)
12 conductors requires 50%

Step 3: Finding correction factors
Ampacity correction factors to **Table 310.16**
128°F requires 76%

Step 4: Finding ampacity
Adjustment and correction factors
30 A x 50% x 76% = 11.4 A

Solution: The ampacity is limited to 11.4 amps for each conductor.

147. Applying correction factors

Step 1: Finding amperage of conductors
Table 310.16
10 AWG THHN = 40 A

Step 2: Finding adjustment factor
Table 310.15(B)(2)(a)
8 conductors requires 70%

Step 3: Finding correction factors

Ampacity correction factors to **Table 310.16**
112°F requires 87%

Step 4: Finding ampacity
Adjustment and correction factors
40 A x 70% x 87% = 24.36 A

Solution: The ampacity is limited to 24.36 amps for each conductor.

148. Applying correction factors

Step 1: Finding amperage of conductors
Table 310.16
12 AWG THHN = 30 A

Step 2: Finding adjustment factor
Table 310.15(B)(2)(a)
6 conductors requires 80%

Step 3: Finding correction factors
Ampacity correction factors to **Table 310.16**
100°F requires 91%

Step 4: Finding ampacity
Adjustment and correction factors
30 A x 80% x 91% = 21.8 A

Solution: The ampacity is limited to 21.8 amps for each conductor.

149. Applying correction factors

Step 1: Finding amperage of conductors
Table 310.16
10 AWG THHN = 40 A

Step 2: Finding adjustment factor
Table 310.15(B)(2)(a)
12 conductors requires 50%

Step 3: Finding correction factors
Ampacity correction factors to **Table 310.16**
125°F requires 76%

Step 4: Finding ampacity
Adjustment and correction factors
40 A x 50% x 76% = 15.2 A

Solution: The ampacity is limited to 15.2 amps for each conductor.

150. Applying 50 percent load diversity factor

Step 1: Finding amperage
Table 310.16
10 AWG THHN cu. = 40 A

Step 2: Calculating ampacity
Table B.310.11
12 conductors = 70%
40 A x 70% = 28 A

Solution: The ampacity of each conductor is 28 amps, however, only 6 conductors can carry this ampacity rating at the same time.

Article 314
Outlet, Device, Pull and Junction Boxes, Conduit Bodies, Fittings, and Handhole Enclosures

151. Sizing octagon box – same size conductors

Step 1: Same size conductors
314.16(B)(1) thru (B)(5)

2 - 12 AWG hots	= 2
2 - 12 AWG neutrals	= 2
2 - 12 AWG grounds	= 1
1 fixture stud	= 1
1 hickey	= 1
2 pigtails	= 0
2 romex connectors	= 0
2 - 16 AWG fixture wires	= 0
Total	= 7

Step 2: Selecting box
Table 314.16(A)
7 – 12 AWG conductors requires 4” x 2-1/8” (100 mm x 54 mm) box

Solution: A 4 in. x 2-1/8 in. (100 mm x 54 mm) octagon box is required.

152. Sizing octagon box – different size conductors

Step 1: Different size conductors
314.16(B)(1) thru (B)(5) and **Table 314.16(B)**

2 - 12 AWG hots	
2.25 cu. in. x 2	= 4.5 cu. in.
2 - 12 AWG neutrals	
2.25 cu. in. x 2	= 4.5 cu. in.
2 - 12 AWG grounds	
2.25 cu. in. x 1	= 2.25 cu. in.
1 fixture stud	
2.25 cu. in. x 1	= 2.25 cu. in.
1 hickey	
2.25 cu. in. x 1	= 2.25 cu. in.
2 pigtails	= 0
2 romex connectors	= 0
2 - 14 AWG fixture wires	
2 cu. in. x 2	= 4.0 cu. in.
Total	= 19.75 cu. in.

Step 2: Selecting box
Table 314.16(A)
19.75 cu. in. requires 4” x 2-1/8” (100 mm x 54 mm) box

Solution: A 4 in. x 2-1/8 in. (100 mm x 54 mm) octagon box is required.

153. Sizing device box – same size conductors

Step 1: Same size conductors
314.16(B)(1) thru (B)(5)

2 - 12 AWG hots	= 2
2 - 12 AWG neutrals	= 2
2 - 12 AWG grounds	= 1
1 receptacle	= 2
2 romex connectors	= 0
Total	= 7

Step 2: Selecting box
Table 314.16(A)
7 - 12 AWG conductors requires 3" x 2" x 3-1/2"
(75 mm x 50 mm x 90 mm)

Solution: A 3 in. x 2 in. x 3-1/2 in. (75 mm x 50 mm x 90 mm) device box is required.

154. Sizing device box - different size conductors

Step 1: Different size conductors
314.16(B)(1) thru (B)(5) and **Table 314.16(B)**

2 - 12 AWG passing through	
2.25 cu. in. x 2	= 4.5 cu. in.
1 - 14 AWG hot	
2 cu. in. x 1	= 2.0 cu. in.
1 - 14 AWG neutral	
2 cu. in. x 1	= 2.0 cu. in.
2 - #12 grounds	
2.25 cu. in. x 1	= 2.25 cu. in.
1 receptacle	
2 cu. in. x 2	= 4.0 cu. in.
1 - 12 AWG bonding jumper	= 0
1 - 12 AWG pigtail	= 0
Total	= 14.75 cu. in.

Step 2: Selecting box
Table 314.16(A)
14.75 cu. in. requires 3" x 2" x 3-1/2" box
(75 mm x 50 mm 90 mm)

Solution: A 3 in. x 2 in. x 3-1/2 in. (75 mm x 50 mm x 90 mm) device box is required.

155. Sizing square box – same size conductors

Step 1: Same size conductors
314.16(B)(1) thru (B)(5)

4 - 10 AWG hots	= 4
4 - 10 AWG neutrals	= 4
4 - 10 AWG EGCs	= 1
2 cable clamps	= 1
Total	= 10

Step 2: Selecting box
Table 314.16(A)
10 - 12 AWG conductors requires 4-11/16" x 1-1/4"
(120 mm x 32 mm)

Solution: A 4-11/16 in. x 1-1/4 in. (120 mm x 32 mm) square box is required.

156. Sizing square box – different size conductors

Step 1: Different size conductors
314.16(B)(1) thru (B)(5) and **Table 314.16(B)**

2 - 10 AWG hots	
2.5 cu. in. x 2	= 5.0 cu. in.
2 - 10 AWG neutrals	
2.5 cu. in. x 2	= 5.0 cu. in.
2 - 10 AWG EGCs	
2.5 cu. in. x 1	= 2.5 cu. in.
2 - 12 AWG hots	
2.25 cu. in. x 2	= 4.5 cu. in.
2 - 12 AWG neutrals	
2.25 cu. in. x 2	= 4.5 cu. in.
2 - 12 AWG EGCs	= 0
2 cable clamps	= 2.5 cu. in.
Total	= 24.0 cu. in.

Step 2: Selecting box
Table 314.16(A)
24 cu. in. requires 4-11/16" x 1-1/4" (120 mm x 32 mm)

Solution: A 4-11/16 in. x 1-1/4 in. (120 mm x 32 mm) square box is required.

157. Sizing junction box - same size conductors

Step 1: Same size conductors
314.16(A)(2)

18 - 12 AWG (9 x 2)	
2.25 cu. in. x 18	= 40.5 cu. in.
18 - 12 AWG (9 x 2)	
2.25 cu. in. x 18	= 40.5 cu. in.
6 - 12 AWG (3 x 2)	
2.25 cu. in. x 6	= 13.5 cu. in.
Total	= 94.5 cu. in.

Step 2: Selecting box
314.16(B) and **Chart**
6" x 4" x 4" (300 mm x 200 mm x 200 mm) = 96 cu. in.
96 cu. in. will contain 94.5 cu. in.

Solution: A 6 in. x 4 in. x 4 in. (300 mm x 200 mm x 200 mm) junction box is required.

158. Sizing junction box – different size conductors

Step 1: Different size conductors
314.16(B)(2)

12 - 8 AWG (6 x 2)	
3 cu. in. x 12	= 36.0 cu. in.
18 - 10 AWG (9 x 2)	
2.5 cu. in. x 18	= 45.0 cu. in.
22 - 12 AWG (11 x 2)	
2.25 cu. in. x 22	= 49.5 cu. in.
28 - 14 AWG (14 x 2)	
2 cu. in. x 28	= 56.0 cu. in.
Total	= 186.5 cu. in.

Step 2: Selecting box
314.16(B) and **Chart**
8" x 6" x 4" (400 mm x 300 mm x 200mm) = 192 cu. in.
192 cu. in. will contain 186.5 cu. in.

Solution: A 8 in. x 6 in. x 4 in. (400 mm x 300 mm x 200 mm) junction box is required.

159. Sizing conduit bodies

Step 1: Finding cross-sectional area
Table 4, Ch. 9 (100% Total area)
1-1/2" EMT raceway = 2.036 sq. in.

Step 2: Calculating size LB

314.16(C)
2.036 sq. in. x 2 = 4.072 sq. in.

Solution: **The LB (conduit body) has to have a crosssectional area of 4.072 sq. in.**

160. Sizing junction boxes - straight pull

Step 1: Finding the multiplier
314.28(A)(1)
Multiplier = 8
Step 2: Calculating length
370.28(A)(1)
3” (78) raceway x 8 = 24”

Solution: **The minimum length of the junction box is 24 in.**

161. Sizing junction boxes - straight pull

Step 1: Finding the multiplier
314.28(A)(1)
Multiplier = 8

Step 2: Calculating length
314.28(A)(1)
4”(103) raceway x 8 = 32”

Solution: **The minimum length of the junction box is 32 in.**

162. Sizing junction boxes – straight pull

Step 1: Finding the multiplier
314.28(A)(1)
Multiplier = 8

Step 2: Calculating length
314.28(A)(1)
3” (78) raceway x 8 = 24”

Solution: **The minimum length of the junction box is 24 in.**

163. Sizing junction boxes – straight pull

Step 1: Finding the multiplier
314.28(A)(1)
Multiplier = 8

Step 2: Calculating length
314.28(A)(1)
4” (103) raceway x 8 = 32”

Solution: **The minimum length of the junction box is 32 in.**

164. Sizing junction boxes – angle pull

Step 1: Finding the multiplier
314.28(A)(2)
Multiplier = 6

Step 2: Calculating length
314.28(A)(2)
3” (78) raceway x 6 = 18”

Solution: **The minimum length of the junction box is 18 in x 18 in.**

165. Sizing junction boxes – angle pull

Step 1: Finding the multiplier
314.28(A)(2)
Multiplier = 6

Step 2: Calculating length
314.28(A)(2)
4” (103) raceway x 6 = 24”

Solution: **The minimum length of the junction box is 24 in x 24 in.**

166. Sizing junction boxes - angle pull

Step 1: Finding the multiplier
314.28(A)(2)
Multiplier = 6

Step 2: Calculating length
314.28(A)(2)

4” (103) raceway x 6	= 24”
	= 3” (78)
	= 2” (53)
	= 1” (27)
Total	= 30”

Solution: **The minimum length of the junction box is 30 in. x 30 in.**

167. Sizing junction boxes - angle pull

Step 1: Finding the multiplier
314.28(A)(2)
Multiplier = 6

Step 2: Calculating length
314.28(A)(2)

4” (103) raceway x 6	= 24”
	= 3” (78)
	= 1” (27)
Total	= 28”

Solution: **The minimum length of the junction box is 28 in. x 28 in.**

Article 366
Auxiliary Gutters

168. Sizing auxiliary gutter

Step 1: Finding sq. in. area
Table 5, Ch. 9

500 KCMIL	= .7073 sq. in.
4/0 AWG THWN	= .3237 sq. in.
2 AWG THWN	= .1158 sq. in.
4 AWG THWN	= .0824 sq. in.

Step 2: Calculating sq. in. area
Table 5, Ch. 9

.7073 sq. in. x 3	= 2.1219 sq. in.
.3237 sq. in. x 3	= .9711 sq. in.
.1158 sq. in. x 3	= .3474 sq. in.
.0824 sq. in. x 3	= .2472 sq. in.
Total	= 3.6876 sq. in.

Step 3: Sizing gutter
366.22
sq. in. area divided by 20% = total fill
3.6876 sq. in. ÷ 20% = 18.438 sq. in.

Step 4: Selecting gutter
Chart
6" x 6" = 36"

Step 5: Applying 75% fill for splices
366.56(A)
sq. in. of gutter x 75% = fill area
36" x 75% = 27 sq. in.

Solution: A 6 in. x 6 in. auxiliary gutter is required with only 27 in. of the gutter space used for splicing conductors.

169. Sizing auxiliary gutter

Step 1: Finding sq. in. area
Table 5, Ch. 9

350 KCMIL	= .5242 sq. in.
1/0 AWG THWN	= .1855 sq. in.
4 AWG THWN	= .0824 sq. in.
8 AWG THWN	= .0366 sq. in.

Step 2: Calculating sq. in. area
Table 5, Ch. 9

.5242 sq. in. x 3	= 1.5726 sq. in.
.1855 sq. in. x 3	= .5565 sq. in.
.0824 sq. in. x 3	= .2472 sq. in.
.0366 sq. in. x 3	= .1098 sq. in.
Total	= 2.4861 sq. in.

Step 3: Sizing gutter
366.22
sq. in. area divided by 20% = total fill
2.4861 sq. in. ÷ 20% = 12.4305 sq. in.

Step 4: Selecting gutter
Chart
4" x 6" = 24"

Step 5: Applying 75% fill for splices
366.56(A)
sq. in. of gutter x 75% = fill area
24" x 75% = 18 sq. in.

Solution: A 4 in. x 6 in. auxiliary gutter is required with only 18 in. of the gutter space used for splicing conductors.

Article 392
Cable Trays

170. Sizing ventilated cable tray

Step 1: Finding sq. in. area
Table 5, Ch. 9
300 KCMIL = .4608 sq. in.
1000 KCMIL = 1.3478 sq. in.

Step 2: Calculating sq. in. area
392.10(A)(2) and **Table 392.10(A), Column 1**

.4608 sq. in. x 12	= 5.5296 sq. in.
1.3478 sq. in. x 10	= 13.478 sq. in.
Total	= 19.0076 sq. in.

Step 3: Selecting size cable tray
Table 392.10(A), Column 1
19.0076 sq. in. requires 18" width tray
18" wide tray requires 19.5 sq. in.

Solution: A 18 in. wide tray has 19.5 sq. in. per Table 392.10(A).

171. Sizing ventilated cable tray

Step 1: Finding sq. in. area
Table 5, Ch. 9
250 KCMIL = .3970 sq. in.
1000 KCMIL = 1.3478 sq. in.

Step 2: Calculating sq. in. area
392.10(A)(2), and **Table 392.10(A), Column 1**

.3970 sq. in. x 14	= 5.558 sq. in.
1.3478 sq. in. x 8	= 10.7824 sq. in.
Total	= 16.3404 sq. in.

Step 3: Selecting size cable tray
Table 392.10(A), Column 1
16.3404 sq. in. requires 18" width tray
18" wide tray requires 19.5 sq. in.

Solution: An 18 in. wide tray has 19.5 sq. in. per Table 392.10(A).

Article 422
Appliances

172. Sizing overcurrent protection device and conductors for appliance

Step 1: Calculating load
422.10(A)
12.5 A x 125% = 15.6 A

Step 2: Selecting OCPD
422.11(A) and **240.4(B)**
15.6 A requires 20 A OCPD

Step 3: Selecting conductors
Table 310.16 and **240.4(D)**
15.6 A requires 12 AWG cu.

Solution: The size overcurrent protection device is 20 amps and the size conductors are 12 AWG THWN copper.

173. Sizing overcurrent protection device and conductors for appliance

Step 1: Calculating load
422.10(A)
15 A x 125% = 18.75 A

Step 2: Selecting OCPD
422.11(A) and **240.4(B)**
18.75 A requires 20 A OCPD

Step 3: Selecting conductors
Table 310.16 and **240.4(D)**
18.75 A requires 12 AWG cu.

Solution: The size overcurrent protection device is 20 amps and the size conductors are 12 AWG THWN copper.

174. Sizing overcurrent protection device and conductors for water heater

Step 1: Finding amperage
I = 5500 VA ÷ 240 V
I = 22.9 A

Step 2: Calculating the A
422.13 and **422.10(A)**
22.9 A x 125% = 28.6 A

Step 3: Selecting conductors
334.80, Table 310.16, and **240.4(D)**
28.6 A load requires 10 AWG cu.

Step 4: Selecting the OCPD
422.13 and **240.4(B)**
28.6 A load requires 30 A OCPD

Solution: **The size overcurrent protection device is 30 amps and the size conductors are 10 AWG THWN copper.**

175. Sizing minimum and maximum overcurrent protection device for nonmotor appliance

Step 1: Calculating minimum OCPD
422.11(E)(3)
15.5 A x 125% = 19.4 A

Step 2: Selecting minimum OCPD
240.4(B) and **240.6(A)**
19.4 A requires 20 A OCPD

Step 3: Calculating maximum OCPD
422.11(E)(3) and **240.4(B)**
15.5 A x 150% = 23.3 A

Step 4: Selecting maximum size
422.11(E)(3) and **240.6(A)**
23.3 A allows 25 A OCPD

Solution: **The minimum size overcurrent protection device is 20 amps and the maximum size overcurrent protection device is 25 amps.**

Article 424
Fixed Electric Space-Heating Equipment

176. Sizing overcurrent protection device and conductors for baseboard heater

Step 1: Calculating load
424.3(A) and **424.3(B)**
40 A x 125% = 50 A

Step 2: Selecting OCPD
240.4(B) and **240.6(A)**
50 A requires 50 A OCPD

Step 3: Selecting conductors
Table 310.16 and **424.3(A)**
50 A requires 8 AWG cu.

Solution: **The size overcurrent protection device required is 50 amps and the size conductors are 8 AWG THWN copper.**

177. Sizing overcurrent protection device and conductors for baseboard heaters

Step 1: Calculating load
424.3(A) and **424.3(B)**
(12 A + 12 A) x 125% = 30 A

Step 2: Selecting OCPD
240.4(B) and **240.6(A)**
30 A requires 30 A OCPD

Step 3: Selecting conductors
Table 310.16 and **424.3(A)**
30 A requires 10 AWG cu.

Solution: **The size overcurrent protection device required is 30 amps and the size conductors are 10 AWG THWN copper.**

178. Sizing overcurrent protection device and conductors for heating unit

Step 1: Calculating amps
424.3(B)
I = (20 kVA x 1000) ÷ 240 V
I = 83 A

Step 2: Calculating load
424.3(B)
(83 A + 3 A) x 125% = 107.5 A

Step 3: Selecting OCPD
240.6(A) and **240.4(B)**
110 A is the next higher standard size

Step 4: Selecting conductors
Table 310.16
107.5 A load requires 2 AWG THWN cu.

Solution: **The size overcurrent protection device required is 110 amps and the size conductors are 2 AWG THWN copper.**

Article 430
Motors, Motor Circuits, and Controllers

179. Sizing conductors for single-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.248**
3 HP = 18.7 A

Step 2: Sizing conductors
430.22(A)
18.7 A x 125% = 23.375 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
23.375 A requires 12 AWG cu.

Solution: **The size conductors are 12 AWG THWN copper.**

180. Sizing conductors for single-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.248**
5 HP = 28 A

Step 2: Sizing conductors
430.22(A)
28 A x 125% = 35 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
35 A requires 10 AWG cu.

Solution: **The size conductors are 10 AWG THWN copper.**

181. Sizing conductors for single-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.248**
1/2 HP = 9.8 A

Step 2: Sizing conductors
430.22(A)
9.8 A x 125% = 12.25 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
12.25 A requires 14 AWG cu.

Solution: **The size conductors are 14 AWG THWN copper.**

182. Sizing conductors for three-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
10 HP = 28 A

Step 2: Sizing conductors
430.22(A)
28 A x 125% = 35 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
35 A requires 10 AWG cu.

Solution: **The size conductors are 10 AWG THWN copper.**

183. Sizing conductors for three-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 88 A

Step 2: Sizing conductors
430.22(A)
88 A x 125% = 110 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
110 A requires 2 AWG cu.

Solution: **The size conductors are 2 AWG THWN copper.**

184. Sizing conductors for three-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
50 HP = 65 A

Step 2: Sizing conductors
430.22(A)
65 A x 125% = 81.25 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
81.25 A requires 4 AWG cu.

Solution: **The size conductors are 4 AWG THWN copper.**

185. Sizing conductors for several three-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
5 HP = 15.2 A
10 HP = 28 A
20 HP = 54 A

Step 2: Sizing conductors
430.24

54 A x 125%	= 67.5 A
28 A x 100%	= 28 A
15.2 A x 100%	= 15.2 A
Total	= 110.7 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
110.7 A requires 2 AWG cu.

Solution: **The size conductors are 2 AWG THWN copper.**

186. Sizing conductors for several three-phase motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
50 HP = 65 A
40 HP = 52 A
30 HP = 40 A

Step 2: Sizing conductors
430.24

65 A x 125%	= 81.25 A
52 A x 100%	= 52 A
40 A x 100%	= 40 A
Total	= 173.25 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
173.25 A requires 2/0 AWG cu.

Solution: **The size conductors are 2/0 AWG THWN copper.**

187. Sizing control circuit conductors inside enclosures

Step 1: Verifying OCPD upstream
430.72(B)(2) and **Table 430.72(B), Column B**
Upstream OCPD = 80 A

Step 2: Determining size conductors from table
Table 430.72(B), Column B
80 A permits 14 AWG cu.

Step 3: Calculating size conductors from **Note 2**

430.72(B)(2), Table 430.72(B), Note 2, and **Table 310.17**
• 14 AWG cu. = 25 A x 400% = 100 A OCPD
• 100 A OCPD permits 14 AWG cu.
• 80 A OCPD is permitted to protect 14 AWG cu.

Solution: **The size control circuit conductors are 14 AWG THWN copper based on an 80 amp overcurrent protection device ahead of the motor's branch-circuit conductors.**

188. Sizing remote control circuit conductors

Step 1: Verifying OCPD upstream
430.72(B)(2) and **Table 430.72(B), Column C**
Upstream OCPD = 80 A

Step 2: Determining size conductors from table
Table 430.72(B), Column C
80 A permits 10 AWG cu.

Step 3: Calculating size conductors from **Note 3**
430.72(B)(2), Table 430.72(B), Note 3, and **Table 310.16**
• 10 AWG cu. requires 30 A OCPD
• 30 A OCPD x 300% = 90 A
• 80 A OCPD is permitted to protect 10 AWG cu.

Solution: **The size control circuit conductors are 10 AWG THWN copper based on a 80 amp overcurrent protection device ahead of the motor's branch-circuit conductors.**

189. Sizing minimum and next size nontime-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 80 A

Step 2: Finding percentage
430.52(C)(1) and **Table 430.52**
Minimum size = 300%

Step 3: Calculating minimum size
430.52(C)(1)
Minimum size = 80 A x 300%
Minimum size = 240 A (round down)

Step 4: Calculating next size
430.52(C)(1), Ex. 1
240 A requires 250 A (round up)

Step 5: Selecting NTDFs
Minimum size = 225 A
Next size = 250 A

Solution: **The minimum size nontime-delay fuse is 225 amps and the next size is 250 amps.**

190. Sizing minimum and next size nontime-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
40 HP = 65 A

Step 2: Finding percentage
430.52(C)(1) and **Table 430.52**
Minimum size = 300%

Step 3: Calculating minimum size
430.52(C)(1)
Minimum size = 65 A x 300%
Minimum size = 195 A (round down)

Step 4: Calculating next size
430.52(C)(1), Ex. 1
195 A requires 200 A (round up)

Step 5: Selecting NTDFs
Minimum size = 175 A
Next size = 200 A

Solution: **The minimum size nontime-delay fuse is 175 amps and the next size is 200 amps.**

191. Sizing minimum and next size time-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
25 HP = 34 A

Step 2: Finding percentage
430.52(C)(1) and **Table 430.52**
Minimum size = 175%

Step 3: Calculating minimum size
430.52(C)(1)
Minimum size = 34 A x 175% = 59.5 A
Minimum size = 59.5 A requires 50 A

Step 4: Calculating next size
430.52(C)(1), Ex. 1
59.5 A requires 60 A

Step 5: Selecting TDFs
Minimum size = 50 A
Next size = 60 A

Solution: **The minimum size time-delay fuse is 50 amps and the next size is 60 amps.**

192. Sizing minimum and next size time-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
20 HP = 59.4 A

Step 2: Finding percentage
430.52(C)(1) and **Table 430.52**
Minimum size = 175%

Step 3: Calculating minimum size (round down)
430.52(C)(1)
Minimum size = 59.4 A x 175% = 103.95 A
103.95 A requires 100 A

Step 4: Calculating next size (round up)
430.52(C)(1), Ex. 1
103.95 A requires 110 A

Step 5: Selecting TDFs
Minimum size = 100 A
Next size = 110 A

Solution: **The minimum size time-delay fuse is 100 amps and the**

next size is 110 amps.

193. Sizing minimum and maximum instantaneous-trip circuit breakers

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 40 A

Step 2: Finding percentage
430.52(C)(3) and **Table 430.52**
Minimum setting = 1100%

Step 3: Calculating minimum setting
430.52(C)(3)
Minimum setting = 40 A x 1100%
Minimum setting = 440 A

Step 4: Calculating maximum setting
430.52(C)(3), Ex. 1
Maximum setting = 40 A x 1700%
Maximum setting = 680 A

Step 5: Selecting instantaneous-trip circuit breaker
Minimum setting = 440 A
Maximum setting = 680 A

Solution: **The minimum instantaneous-trip circuit breaker setting is 440 amps and the maximum setting is 680 amps.**

194. Sizing minimum and next size inverse-time circuit breaker

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 88 A

Step 2: Finding percentage
430.52(C)(1) and **Table 430.52**
Minimum size = 250% x 88 A = 220 A

Step 3: Calculating minimum size (round down)
430.52(C)(1)
220 A requires 200 A

Step 4: Calculating next size (round up)
430.52(C)(1), Ex. 1
220 A requires 225 A

Step 5: Selecting inverse-time circuit breaker
Minimum size = 200 A
Next size = 225 A

Solution: **The minimum size inverse-time circuit breaker is 200 amps and the next size is 225 amps.**

195. Sizing minimum and next size inverse-time circuit breaker

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
200 HP = 192 A

Step 2: Finding percentage
430.52(C)(1) and **Table 430.52**
Minimum size = 250% x 192 A = 480 A

Step 3: Calculating minimum size (round down)
430.52(C)(1)
480 A requires 450 A

Step 4: Calculating next size (round up)
430.52(C)(1), Ex. 1
480 A requires 500 A

Step 5: Selecting inverse-time circuit breaker
Minimum size = 450 A
Next size = 500 A

Solution: **The minimum size inverse-time circuit breaker is 450 amps and the next size is 500 amps.**

196. Sizing maximum nontime-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 80 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(a)
Maximum size = 400%

Step 3: Calculating maximum size
430.52(C)(1), Ex. 2(a)
Maximum size = 80 A x 400%
Maximum size = 320 A

Step 4: Selecting NTDFs (round down)
Maximum size = 300 A

Solution: **The maximum size nontime-delay fuse is 300 amps.**

197. Sizing maximum nontime-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
40 HP = 52 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(a)
Maximum size = 400%

Step 3: Calculating maximum size
430.52(C)(1), Ex. 2(a)
Maximum size = 52 A x 400%
Maximum size = 208 A

Step 4: Selecting NTDFs (round down)
Maximum size = 200 A

Solution: **The maximum size nontime-delay fuse is 200 amps.**

198. Sizing maximum time-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 40 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(b)
Maximum size = 225%

Step 3: Calculating maximum size
430.52(C)(1), Ex. 2(b)
Maximum size = 40 A x 225%

Maximum size = 90 A

Step 4: Selecting TDFs
Maximum size = 90 A

Solution: The maximum size time-delay fuse is 90 amps.

199. Sizing maximum time-delay fuses

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
20 HP = 54 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(b)
Maximum size = 225%

Step 3: Calculating maximum size
430.52(C)(1), Ex. 2(b)
Maximum size = 54 A x 225%
Maximum size = 121.5 A

Step 4: Selecting TDFs (round down)
Maximum size = 110 A

Solution: The maximum size time-delay fuse is 110 amps.

200. Sizing maximum inverse-time circuit breaker

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
30 HP = 88 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(c)
Maximum size = 400%

Step 3: Calculating maximum size
430.52(C)(1), Ex. 2(c)
Maximum size = 88 A x 400%
Maximum size = 352

Step 4: Selecting inverse-time circuit breaker (round down)
Maximum size = 350 A

Solution: The maximum size inverse-time circuit breaker is 350 amps.

201. Sizing maximum inverse-time circuit breaker

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
50 HP = 65 A

Step 2: Finding percentage
430.52(C)(1), Ex. 2(c)
Maximum size = 400%

Step 3: Calculating maximum size (round down)
430.52(C)(1), Ex. 2(c)
Maximum size = 65 A x 400%
Maximum size = 260

Step 4: Selecting inverse-time circuit breaker
Maximum size = 250 A

Solution: The maximum size inverse-time circuit breaker is 250 amps.

202. Sizing feeder overcurrent protection device for motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
5 HP = 15.2 A
10 HP = 28 A
15 HP = 42 A
20 HP = 54 A

Step 2: Calculating feeder OCPD
430.52(A), Table 430.52, and **430.62(A)**
54 A x 250% = 135 A

(Round up)	= 150 A
	= 42 A
	= 28 A
	= 15.2 A
Total load	= 235.2 A

Step 3: Selecting OCPD
430.62(A), 240.4(G), and **240.6(A)**
235.2 A requires 200 A OCPD

Solution: The size overcurrent protection device is 200 amps.

203. Sizing feeder overcurrent protection device for motors

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
20 HP = 27 A
30 HP = 40 A
40 HP = 52 A

Step 2: Calculating feeder OCPD
430.52(A), Table 430.52, and **430.62(A)**
52 A x 250% = 130 A

(Round up)	= 150 A
	= 40 A
	= 27 A
Total load	= 217 A

Step 3: Selecting OCPD (round down)
430.62(A), 240.4(G), and **240.6(A)**
217 A requires 200 A OCPD

Solution: The size overcurrent protection device is 200 amps.

204. Sizing minimum overload protection

Step 1: Finding FLC
430.6(A)(2)
Nameplate = 45 A

Step 2: Finding percentage
430.32(A)(1)
SF = 125%
TR = 125%

Step 3: Calculating FLC
430.32(A)(1)
45 A x 125% = 56.25 A

Step 4: Selecting OLRs
430.32(A)(1)
56.25 A requires 56.25 A

Solution: The minimum size overload protection is 56.25 amps.

205. Sizing maximum overload protection

Step 1: Finding FLC
430.6(A)(2)
Nameplate = 45 A

Step 2: Finding percentage
430.34
SF = 140%
TR = 140%

Step 3: Calculating FLC
430.34
45 A x 140% = 63 A

Step 4: Selecting TDFs
430.32(C)
63 A requires 63 A

Solution: The maximum size overload protection is 63 amps.

206. Finding overcurrent protection device for control circuit conductors located in controller

Step 1: Finding amperage
Table 310.17 and **Table 430.72(B), Note 2**
14 AWG = 25 A

Step 2: Applying percentage
430.72(B)(2) and **Table 430.72(B), Note 2**
25 A x 400% = 100 A

Solution: The size overcurrent protection device is 100 amps.

207. Sizing overcurrent protection device for control circuit conductors that are run remotely.

Step 1: Finding amperage
Table 310.16 and **Table 430.72(B), Note 3**
14 AWG = 20 A
Step 2: Applying percentage based on OCPD
430.72(B)(2) and **430.72(B), Note 3**
15 A x 300% = 45 A

Solution: The size overcurrent protection device is 45 amps.

208. Sizing overcurrent protection device in the primary side of a control transformer

Step 1: Finding amperage
430.72(C)(2)
I = VA ÷ V
I = 2800 VA ÷ 480 V
I = 5.8 A

Step 2: Applying percentage
430.72(C)(2) and **Table 450.3(B)**
5.8 A x 167% = 9.68 A

Step 3: Selecting OCPD
240.6(A)
9.68 A requires 6 A

Solution: The size overcurrent protection device is 6 amps.

209. Sizing overcurrent protection device in secondary side of a control transformer

Step 1: Finding ratio of transformer
Primary and secondary
725.24(D) and **Table 310.16**
Ratio = (240 V sec. ÷ 480 V pri.) x 20 A
Ratio = 10 A

Step 2: Selecting OCPD for control circuit
725.24(D) and **240.6(A)**
10 A requires 10 A

Solution: The size overcurrent protection device is 10 amps.

Article 440
Air-Conditioning and Refrigerating Equipment

210. Sizing conductors to an air-conditioning unit

Step 1: Calculating amps
440.32
22 A x 125% = 27.5 A
2.5 A x 100% = 2.5 A
Total load = 30 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
30 A requires 10 AWG cu.

Solution: The size conductors are 10 AWG THWN copper.

211. Sizing conductors to an air-conditioning unit

Step 1: Calculating amps
440.32
18 A x 125% = 22.5 A
2 A x 100% = 2 A
Total load = 24.5 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
24.5 A requires 12 AWG cu.

Solution: The size conductors are 12 AWG THWN copper.

212. Sizing conductors to an air-conditioning unit

Step 1: Calculating amps
440.32
37 A x 125% = 46.25 A
3 A x 100% = 3 A
Total load = 49.25 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
49.25 A requires 8 AWG cu.

Solution: The size conductors are 8 AWG THWN copper.

213. Sizing conductors for several air-conditioning units

Step 1: Calculating amps
440.33
24 A x 125% + 2.5 A = 32.5 A
24 A x 100% + 2.5 A = 26.5 A
24 A x 100% + 2.5 A = 26.5 A
Total load = 85.5 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
85.5 A requires 3 AWG cu.

Solution: The size conductors are 3 AWG THWN copper.

214. Sizing conductors for several air-conditioning units

Step 1: Calculating amps
440.33
32 A x 125% + 3 A = 43 A
26 A x 100% + 2.5 A = 28.5 A
24 A x 100% + 2.5 A = 26.5 A
Total load = 98 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
98 A requires 3 AWG cu.

Solution: The size conductors are 3 AWG THWN copper.

215. Sizing overcurrent protection device for air-conditioning unit

Step 1: Sizing minimum OCPD
440.22(A)
24 A x 175% + 2.5 A = 44.5 A

Step 2: Selecting OCPD (round down)
240.4(G) and **240.6(A)**
44.5 A requires 40 A OCPD

Solution: The minimum size overcurrent protection device is 40 amps.

216. Sizing overcurrent protection device for air-conditioning unit

Step 1: Sizing minimum OCPD
440.22(A)
32 A x 175% + 3 A = 59 A

Step 2: Selecting OCPD (round down)
240.4(G) and **240.6(A)**
59 A requires 50 A OCPD

Solution: The minimum size overcurrent protection device is 50 amps.

217. Sizing overcurrent protection device for air-conditioning unit

Step 1: Sizing maximum OCPD
440.22(A)
24 A x 225% + 2.5 A = 56.5 A

Step 2: Selecting OCPD (round down)
240.4(G) and **240.6(A)**
56.5 A requires 50 A OCPD

Solution: The maximum size overcurrent protection device is 50 amps.

218. Sizing overcurrent protection device for air-conditioning unit

Step 1: Sizing maximum OCPD
440.22(A)
32 A x 225% + 3 A = 75 A

Step 2: Selecting OCPD (round down)
240.4(G) and **240.6(A)**
75 A requires 70 A OCPD

Solution: The maximum size overcurrent protection device is 70 amps.

Article 450
Transformers and Transformer Vaults

219. Sizing overcurrent protection device for transformer secondary circuits

Step 1: Finding ratio amps
240.4(F)
OCPD = 240 V ÷ 480 V x 150 A
OCPD = 75 A (round down)

Solution: The size overcurrent protection device is 70 amps.

220. Sizing overcurrent protection device for transformer secondary circuits

Step 1: Finding ratio amps
240.4(F)
OCPD = 240 V ÷ 480 V x 335 A
OCPD = 167.5 A (round down)

Solution: The size overcurrent protection device is 150 amps.

221. Sizing overcurrent protection device for primary side of transformer

Step 1: Finding FLA of primary
Table 450.3(A)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (1500 kVA x 1000) ÷ (12,470 V x 1.732)
FLA = 69.45 A

Step 2: Calculating FLA for OCPD
Table 450.3(A)
69.45 A x 300% = 208.35 A

Step 3: Selecting OCPD (round down)
Table 450.3(A) and **240.6(A)**
208.35 A requires 225 A

Solution: The size circuit breaker is 225 amps.

222. Sizing overcurrent protection device for secondary and primary of transformer - nonsupervised location

Step 1: Finding FLA of transformer (primary)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (450 kVA x 1000) ÷ (4160 V x 1.732)
FLA = 62.46

Step 2: Calculating FLA for OCPD (primary)
450.3(A) and **Table 450.3(A)**
FLA = 62.46 x 600%

FLA = 374.76 A

Step 3: Selecting OCPD (primary)
Table 450.3(A) and **240.6(A)**
374.76 A requires 400 A OCPD

Step 4: Finding FLA of transformer (secondary)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (450 kVA x 1000) ÷ (480 V x 1.732)
FLA = 541.5

Step 5: Calculating FLA for OCPD (secondary)
450.3(A) and **Table 450.3(A)**
FLA = 541.5 A x 125%
FLA = 676.9 A

Step 6: Selecting OCPD (secondary)
450.3(A) and **240.6(A)** (round up)
676.9 A requires 700 A OCPD

Solution: **The size overcurrent protection device for the primary side is 400 amps and the secondary side is 700 amps.**

223. Sizing overcurrent protection device for secondary and primary of transformer, supervised location

Step 1: Finding FLA of transformer (primary)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (450 kVA x 1000) ÷ (4160 V x 1.732)
FLA = 62.46

Step 2: Calculating FLA for OCPD (primary)
450.3(A) and **Table 450.3(A)**
FLA = 62.46 x 600%
FLA = 374.76 A

Step 3: Selecting OCPD (primary)
450.3(A) and **240.6(A)** (round down)
374.76 A requires 350 A OCPD

Step 4: Finding FLA of transformer (secondary)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (450 kVA x 1000) ÷ (480 V x 1.732)
FLA = 541.5

Step 5: Calculating FLA for OCPD (secondary)
450.3(A) and **Table 450.3(A)**
FLA = 541.5 A x 250%
FLA = 1353.8 A

Step 6: Selecting OCPD (secondary)
450.3(A) and **240.6(A)** (round down)
1353.8 A requires 1200 A OCPD

Solution: **The size overcurrent protection device for the primary side is 350 amps and the size for the secondary side is 1200 amps.**

224. Sizing overcurrent protection device in the primary side only

Step 1: Finding FLA of primary
FLA = (kVA x 1000) ÷ V
FLA = (20 kVA x 1000) ÷ 240 V
FLA = 83.3 A

Step 2: Calculating OCPD
450.3(B) and **Table 450.3(B)**
83.3 A x 125% = 104.1 A

Step 3: Selecting OCPD
Table 450.3(B) and **240.6(A)**
104.1 A requires 110 A

Solution: **The size overcurrent protection device in the primary side is 110 amps.**

225. Sizing overcurrent protection device in the primary side

Step 1: Finding FLA of primary
FLA = (kVA x 1000) ÷ V
FLA = (3 kVA x 1000) ÷ 480 V
FLA = 6.25 A

Step 2: Calculating OCPD
Table 450.3(B)
6.25 A x 167% = 10.4 A

Step 3: Selecting OCPD
Table 450.3(B) and **240.6(A)**
10.4 A requires 10 A

Solution: **The size overcurrent protection device is 10 amps.**

226. Sizing minimum and maximum overcurrent protection device on the primary side

Step 1: Finding FLA of transformer
FLA = (kVA x 1000) ÷ V
FLA = (.6 kVA x 1000) ÷ 480 V
FLA = 1.25 A

Step 2: Calculating OCPD (minimum)
Table 450.3(B)
1.25 A x 300% = 3.75 A

Step 3: Selecting OCPD (minimum)
T**able 450.3(B)** and **240.6(A)**
3.75 A requires 3 A

Step 4: Calculating OCPD (maximum)
430.72(C)(4)
1.25 A x 500% = 6.25 A

Step 5: Selecting OCPD (maximum)
430.72(C)(4) and **240.6(A)**
6.25 A requires 6 A

Solution: **The minimum size overcurrent protection device in the primary is 3 amps and the maximum size overcurrent protection device is 6 amps.**

227. Sizing overcurrent protection device for primary and secondary side of transformer

Step 1: Finding FLA of primary
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (30 kVA x 1000) ÷ (480 V x 1.732)
FLA = 36.1 A

Step 2: Calculating OCPD (primary)

Table 450.3(B)
36.1 A x 250% = 90.25 A

Step 3: Selecting OCPD (primary)
Table 450.3(B) and **240.6(A)**
90.25 A requires 90 A

Step 4: Finding FLA of secondary
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (30 kVA x 1000) ÷ (240 V x 1.732)
FLA = 72.1 A

Step 5: Calculating OCPD (secondary)
Table 450.3(B)
72.1 A x 125% = 90.1 A

Step 6: Selecting OCPD (secondary)
Table 450.3(B) and **240.6(A)**
90.1 A requires 100 A

Solution: **The size overcurrent protection device for the primary side is 90 amps and the size overcurrent protection device for the secondary side is 100 amps.**

228. Sizing overcurrent protection device for primary and secondary side of transformer

Step 1: Finding FLA of primary
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (50 kVA x 1000) ÷ (480 V x 1.732)
FLA = 60.2 A

Step 2: Calculating OCPD (primary)
Table 450.3(B)
60.2 A x 250% = 150.5 A

Step 3: Selecting OCPD (primary)
Table 450.3(B) and **240.6(A)**
150.5 A requires 150 A

Step 4: Finding FLA of secondary
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (50 kVA x 1000) ÷ (240 V x 1.732)
FLA = 120.2 A

Step 5: Calculating OCPD (secondary)
Table 450.3(B)
120.2 A x 125% = 150.25 A

Step 6: Selecting OCPD (secondary)
Table 450.3(B) and **240.6(A)**
150.25 A requires 175 A

Solution: **The size overcurrent protection device for the primary side is 150 amps and the size overcurrent protection device for the secondary side is 175 amps.**

Article 455
Phase Converters

229. Sizing the conductors for phase converters

Step 1: Finding FLC
430.6(A)(1) and **Table 430.250**
20 HP = 54 A

Step 2: Sizing conductors
455.6(A)(2)
54 A x 250% = 135 A

Step 3: Selecting conductors
310.10, FPN and **Table 310.16**
135 A requires 1/0 AWG cu.

Solution: **The size conductors are 1/0 AWG THWN copper.**

230. Sizing overcurrent protection device for phase converters

Step 1: Finding FLC of motor
430.6(A)(1) and **Table 430.250**
25 HP = 68 A

Step 2: Sizing OCPD
455.7(B) and **455.6(A)(2)**
68 A x 250% = 170 A

Step 3: Selecting OCPD
455.7(B), 455.6(A)(2), 240.4(G), and **240.6(A)**
170 A requires 175 A

Solution: **The size overcurrent protection device for the phase converter is 175 amps.**

Article 460
Capacitors

231. Capacitor circuit conductors

Step 1: Calculating conductors at 1/3
460.8(A) and **Table 310.16**
3 AWG = 100 A ÷ 1/3 = 33.3 A

Step 2: Selecting conductors
310.10, FPN and **Table 310.16**
33.3 A requires 10 AWG cu.

Step 3: Calculating FLA of capacitor
460.8(A)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (20 kVA x 1000) ÷ (460 V x 1.732)
FLA = 25 A
FLA = 25 A x 135%
FLA = 33.75 A

Step 4: Selecting conductors
310.10, FPN and **Table 310.16**
33.75 A requires 10 AWG cu.

Solution: **The size conductors are 10 AWG THWN copper.**

232. Sizing disconnect and overcurrent protection device for capacitor

Step 1: Calculating FLA of capacitor
460.8(C)(3)
FLA = (kVA x 1000) ÷ (V x √3)
FLA = (25 kVA x 1000) ÷ (208 V x 1.732)
FLA = 69.4
FLA = 69.4 x 135%
FLA = 93.69 A

Step 2: Calculating disconnect
460.8(C)(3) and **240.6(A)**
93.69 A requires 100 A

Solution: **The size disconnect switch is 100 amps**

Article 550
Mobile Homes, Manufactured Homes, and Mobile Home Parks

233. Finding lighting circuits for mobile home

Step 1: Finding sq. ft VA
550.12(A)
900 sq. ft x 3 VA = 2700 VA

Step 2: Finding circuit breaker VA
550.4(A)
15 A x 120 V = 1800 VA

Step 3: Calculating number of lighting circuits
2700 VA ÷ 1800 VA = 1.5

Step 4: Selecting # of lighting circuits
550.4(A)
1.5 = 2 - 15 amp, two-wire circuits

Solution: **Two 15 amp, two-wire circuits are required.**

234. Sizing fixed-appliance load – mobile home

Step 1: Finding range VA
8.5 kVA = 8500 VA

Step 2: Calculating range VA
8500 VA x 80% = 6800 VA

Solution: **The range is 6800 volt-amps.**
Step 1: Calculating load (fixed appliances)
550.18(B)(2), (B)(3), and **(B)(4)**

Water heater	= 6,000 VA
Disposal	= 450 VA
Dishwasher	= 700 VA
Heating	= 5,500 VA
Largest motor (450 VA x 25%)	= 113 VA
Total load	= 12,763 VA

Solution: **The fixed-appliance load is 12,763 volt-amps.**

235. Sizing overcurrent protection device and THWN copper conductors

Step 1: Finding amps for branch circuit
600.5(B) and **210.19(A)(1)**
1.5 A x 10 = 15 A

Step 2: Calculating amps for branch circuit
600.5(B) and **210.19(A)(1)**
15 A x 125% = 18.75 A

Step 3: Selecting OCPD for branch circuit
Table 310.16, 240.4(D), 240.4(B), and **240.6(A)**
18.75 A requires 20 A OCPD

Step 4: Selecting conductors for branch circuit
310.10, FPN, Table 310.16, and **240.4(D)**
20 A Requires 12 AWG cu.

Solution: **The size overcurrent protection device required is 20 amps and the size conductors are 12 AWG THWN copper.**

236. Finding VA for lighting load

Step 1: Finding VA (noncontinuous)
220.14(F) and **600.5(A)**
1800 VA x 100% = 1800 VA

Solution: **The lighting load is 1800 volt-amps.**

237. Finding VA for lighting load

Step 1: Finding VA (continuous)
220.14(F) and **600.5(A)**
2400 VA x 125% = 3000 VA

Solution: **The lighting load is 3000 volt-amps.**

Article 630
Electric Welders

238. Sizing conductors to an arc welder without motor

Step 1: Finding FLC
630.11(A)
Welder = 58 A

Step 2: Finding multiplier
630.11(A) and **Table 630.11(A)**
Multiplier = .84
Step 3: Calculating amps
630.11(A) and **Table 630.11(A)**
58 A x 84% = 48.72 A

Step 4: Selecting conductors
Table 310.16
48.72 A requires 8 AWG cu.

Solution: **The size conductors are 8 AWG THWN copper.**

239. Sizing conductors to an arc welder

Step 1: Finding FLC
630.11(A)
Welder = 42 A

Step 2: Finding multiplier
630.11(A) and **Table 630.11(A)**
Multiplier = .71

Step 3: Calculating amps
630.11(A) and **Table 630.11(A)**
42 A x 71% = 29.82 A

Step 4: Selecting conductors
Table 310.16
29.82 A requires 10 AWG cu.

Solution: **The size conductors are 10 AWG THWN copper.**

240. Sizing conductors to an arc welder with motor

Step 1: Finding FLC
630.11(A)
Welder = 68 A

Step 2: Finding multiplier
630.11(A) and **Table 630.11(A)**
Multiplier = .91

Step 3: Calculating amps
630.11(A) and **Table 630.11(A)**
68 A x 91% = 61.88 A

Step 4: Selecting conductors
Table 310.16
61.88 A requires 6 AWG cu.

Solution: **The size conductors are 6 AWG THWN copper.**

241. Sizing conductors to resistance welders

Step 1: Finding FLC
630.31(A)(2) and **Table 630.31(A)(2)**
Welder = 84 A

Step 2: Finding multiplier
630.31(A)(2) and **Table 630.31(A)(2)**
Multiplier = .71

Step 3: Calculating amps
630.31(A)
84 A x 71% = 59.64 A

Step 4: Selecting conductors
Table 310.16
59.64 A requires 6 AWG cu.

Solution: **The size conductors are 6 AWG THWN copper.**

242. Sizing overcurrent protection device for an arc welder without motor

Step 1: Finding FLC (conductors)
630.11(A)
Welder = 62 A

Step 2: Finding multiplier (conductors)
Table 630.11(A)
Multiplier = 95%

Step 3: Calculating amps (conductors)
630.11(A)
62 A x 95% = 58.9 A

Step 4: Selecting conductors (branch circuits)
Table 310.16
58.9 requires 6 AWG cu.

Step 5: Finding multiplier (OCPD)
630.12(A) and **630.12(B)**
Multiplier = 200%

Step 6: Calculating amps (OCPD)
630.12(A) and **630.12(B)**
62 A x 200% = 124 A

Step 7: Selecting OCPD for disconnect
240.4(G), 240.6(A), and **630.12(B)**
124 A requires 110 A

Step 8: Protecting conductors (branch circuits)
630.12(B)
6 AWG THWN cu. = 65 A
65 A x 200% = 130 A
130 A requires 125 A

Solution: **The size overcurrent protection device for the conductors is 125 amps and the size disconnect is 110 amps.**

243. Sizing overcurrent protection device for an arc welder with motor

Step 1: Finding FLC
630.11(A) and **630.11(B)**
Welder = 58 A

Step 2: Finding multiplier
630.11(A) and **630.12(A)** and **(B)**
Multiplier = 200%

Step 3: Calculating amps
630.12(A) and **630.12(B)**
58 A x 200% = 116 A

Step 4: Selecting OCPD for disconnect
240.6(A), 630.13, and **630.32(A)**
116 A requires 110 A

Solution: **The size overcurrent protection device required is 110 amps.**

244. Sizing overcurrent protection device for resistance welder

Step 1: Finding FLC (conductors)
630.31(A)(2)
Welder = 78 A

Step 2: Finding multiplier (conductors)
Table 630.31(A)(2)
Multiplier = 63%

Step 3: Calculating amps (conductors)
630.31(A)(2)
78 A x 63% = 49.14 A

Step 4: Selecting conductors (THWN cu.)
Table 310.16
49.14 A requires 8 AWG cu.

Step 5: Finding multiplier (OCPD)
630.32(A)
Multiplier = 300%

Step 6: Calculating amps for OCPD at welder
630.32(A)
78 A x 300% = 234 A

Step 7: Selecting OCPD for disconnecting means
240.4(G), 240.6(A), and **630.32(A)**
234 A requires 200 A

Step 8: Protecting conductors
630.32(B)
8 AWG THWN cu. = 50 A
50 A x 300% = 150 A
150 A requires 150 A

Solution: The size overcurrent protection device required is 150 amps and the size disconnect is 150 amps.

Chapter 9
Tables

245. Sizing electrical metallic tubing – different size conductors

Step 1: Finding sq. in. area
Table 5, Ch. 9
6 AWG = .0507 sq. in.
8 AWG = .0366 sq. in.
10 AWG = .0211 sq. in.

Step 2: Calculating sq. in. area

.0507 sq. in. x 2	= .1014 sq. in.
.0366 sq. in. x 2	= .0732 sq. in.
.0211 sq. in. x 4	= .0844 sq. in.
Total	= .259 sq. in.

Step 3: Selecting size conduit
Table 4, Ch. 9
.259 sq. in. requires .346 sq. in.

Solution: A 1 in. (27) electrical metallic tubing is required.

246. Sizing rigid metal conduit – different size conductors

Step 1: Finding sq. in. area
Table 5, Ch. 9
8 AWG = .0366 sq. in.
10 AWG = .0211 sq. in.
12 AWG = .0133 sq. in.

Step 2: Calculating sq. in. area

.0366 sq. in. x 4	= .1464 sq. in.
.0211 sq. in. x 8	= .1688 sq. in.
.0133 sq. in. x 12	= .1596 sq. in.
Total	= .4748 sq. in.

Step 3: Selecting size conduit
Table 4, Ch. 9
.4748 sq. in. requires .610 sq. in.

Solution: A 1-1/4 in. (35) rigid metal conduit is required.

247. Sizing PVC (schedule 40) – different size conductors

Step 1: Finding sq. in. area
Table 5, Ch. 9
1/0 AWG = .1825 sq. in.
2 AWG = .1146 sq. in.
6 AWG = .059 sq. in.

Step 2: Calculating sq. in. area

.1825 sq. in. x 4	= .73 sq. in.
.1146 sq. in. x 4	= .4584 sq. in.
.059 sq. in. x 4	= .236 sq. in.
Total	= 1.4244 sq. in.

Step 3: Selecting size conduit
Table 4, Ch. 9
1.4244 sq. in. requires 1.878 sq. in.

Solution: A 2-1/2 in. (63) PVC (schedule 40) is required.

248. Sizing nipples - same size conductors

Step 1: Finding sq. in. area
Table 5, Ch. 9
12 AWG = .0133 sq. in.

Step 2: Calculating sq. in. area
Table 5, Ch. 9
.0133 sq. in. x 28 = .3724 sq. in.

Step 3: Finding conduit at 100% total fill
Table 4, Ch. 9
1" conduit has a 100% total of .864 sq. in.

Step 4: Applying 60% fill
Note (4) to **Ch. 9**
sq. in. area x 60% = fill area
.864 sq. in. x 60% = .5184 sq. in.

Step 5: Selecting the nipple
Table 4, Ch. 9
.5184 sq. in. is greater than .3724 sq. in.

Solution: The nipple is 1 (27) in.

249. Sizing nipples - different size conductors

Step 1: Finding sq. in. area
Table 5, Ch. 9
10 AWG = .0211 sq. in.
12 AWG = .0133 sq. in.
14 AWG = .0097 sq. in.

Step 2: Calculating sq. in. area
Table 5, Ch. 9

.0211 sq. in. x 28	= .5908 sq. in.
.0133 sq. in. x 16	= .2128 sq. in.
.0097 sq. in. x 12	= .1164 sq. in.
Total	= .92 sq. in.

Step 3: Finding conduit at 100% total fill
Table 4, Ch. 9
1 1/2" conduit has a 100% total of 2.036 sq. in.

Step 4: Applying 60% fill
Note (4) to **Ch. 9**
sq. in. area x 60% = fill area
2.036 sq. in. x 60% = 1.2216 sq. in.

Step 5: Selecting the nipple
Table 4, Ch. 9
1.2216 sq. in. is greater than .92 sq. in.

Solution: The nipple is 1-1/2 in. (41).

250. Sizing nipples – different size conductors

Step 1: Finding sq. in. area
Table 5, Ch. 9
12 AWG = .0133 sq. in.
10 AWG = .0211 sq. in.
6 AWG = .0507 sq. in.

Step 2: Calculating sq. in. area
Table 5, Ch. 9

.0133 sq. in. x 14	= .1862 sq. in.
.0211 sq. in. x 10	= .211 sq. in.
.0507 sq. in. x 4	= .2028 sq. in.
Total	= .60 sq. in.

Step 3: Finding conduit at 100% total fill
Table 4, Ch. 9
1 1/4" conduit has a 100% total of 1.496 sq. in.

Step 4: Applying 60% fill
Note (4) to Ch. 9
sq. in. area x 60% = fill area
.496 sq. in. x 60% = .8976 sq. in.

Step 5: Selecting the nipple
Table 4, Ch. 9
8976 sq. in. is greater than .60 sq. in.

Solution: **The nipple is 1-1/4 in. (35).**