Chapter E 900

TABLES AND EXAMPLES

A. TABLES

Tables 1, 2 and 3 apply only to complete conduit systems, and do not apply to short sections of conduit used for the protection of exposed wiring from physical damage.

TABLE 1

MAXIMUM NUMBER OF CONDUCTORS IN TRADE SIZES OF CONDUIT OR TUBING

Derating factors for more than three conductors in raceways, see tables E 310.12 through E 310.15, Note 8

Types RF-2, RFH-2, R, RH, RW, RH-RW, RHW, RHH, RU, RUH, RUW, SF and SFF

Types TF, T, TW, and THW
(See sections E 300.17, E 300.18, E 346.06 and E 348.06)

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % conductor fill, Table 3, Chapter E-900, for new work)											
	½ Inch	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch	3½ Inch	4 Inch	5 Inch	6 Inch
18	7	12	20	35	49	80	115	176				
16	6	10	17	30	41	68	98	150				
14	4	6	10	18	25	41	58	90	121	155		
12	3	5	8	15	21	34	50	76	103	132	208	
10	1	4	7	13	17	29	41	64	86	110	173	
8	1	3	4	7	10	17	25	38	52	67	105	152
6	1	1	3	4	6	10	15	23	32	41	64	93
4	1	1	1	3*	5	8	12	18	24	31	49	72
3		1	1	3	4	7	10	16	21	28	44	63
2		1	1	3	3	6	9	14	19	24	38	55
1		1	1	1	3	4	7	10	14	18	29	42
0			1	1	2	4	6	9	12	16	25	37
00			1	1	1	3	5	8	11	14	22	32
000			1	1	1	3	4	7	9	12	19	27
0000				1	1	2	3	6	8	10	16	23
250				1	1	1	3	5	6	8	13	19
300				1	1	1	3	4	5	7	11	16
350				1	1	1	1	3	5	6	10	15
400					1	1	1	3	4	6	9	13
500					1	1	1	3	4	5	8	11
600						1	1	1	3	4	6	9
700						1	1	1	3	3	6	8
750						1	1	1	3	3	5	8
800						1	1	1	2	3	5	7
900						1	1	1	1	3	4	7
1000						1	1	1	1	3	4	6
1250							1	1	1	1	3	5
1500								1	1	1	3	4
1750								1	1	1	2	4
2000								1	1	1	1	3

*Where an existing service run of conduit or electrical metallic tubing does not exceed 50 ft. in length and does not contain more than the equivalent of two quarterbends from end to end, two No. 4 insulated and one No. 4 bare conductors may be installed in 1-inch conduit or tubing.

TABLE 2

TRADE SIZES OF CONDUIT OR TUBING FOR NUMBER OF CONDUCTORS

Lead-Covered Types RL and RHL–600 V.

(See sections E 346.06 and E 348.06)

Size AWG MCM	Number of Conductors in One Conduit or Tubing											
	Single Conductor Cable				2-Conductor Cable				3-Conductor Cable			
	1	2	3	4	1	2	3	4	1	2	3	4
14	½	¾	¾	1	¾	1	1	1¼	¾	1¼	1½	1½
12	½	¾	¾	1	¾	1	1¼	1¼	1	1¼	1½	2
10	½	¾	1	1	¾	1¼	1¼	1½	1	1½	2	2
8	½	1	1¼	1½	1	1¼	1½	2	1	2	2	2½
6	¾	1¼	1½	1½	1¼	1½	2	2½	1¼	2½	3	3
4	¾	1¼	1½	1½	1¼	2	2½	2½	1½	3	3	3½
3	¾	1¼	1½	2	1¼	2	2½	3	1½	3	3	3½
2	1	1¼	1½	2	1¼	2	2½	3	1½	3	3½	4
1	1	1½	2	2	1½	2½	3	3½	2	3½	4	5
0	1	2	2	2½	2	2½	3	3½	2	4	5	5
00	1	2	2	2½	2	3	3½	4	2½	4	5	5
000	1¼	2	2½	2½	2	3	3½	4	2½	5	5	6
0000	1¼	2½	2½	3	2½	3	3½	5	3	5	6	6
250	1¼	2½	3	3	-----	-----	-----	-----	3	6	6	-----
300	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
350	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
400	1½	3	3	3½	-----	-----	-----	-----	3½	6	6	-----
500	1½	3	3½	4	-----	-----	-----	-----	4	6	-----	-----
600	2	3½	4	5	-----	-----	-----	-----	-----	-----	-----	-----
700	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
750	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
800	2	4	5	5	-----	-----	-----	-----	-----	-----	-----	-----
900	2½	4	5	5	-----	-----	-----	-----	-----	-----	-----	-----
1000	2½	5	5	6	-----	-----	-----	-----	-----	-----	-----	-----
1250	3	5	5	6	-----	-----	-----	-----	-----	-----	-----	-----
1500	3	5	6	6	-----	-----	-----	-----	-----	-----	-----	-----
1750	3	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----
2000	3½	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----

The above sizes apply to straight runs or with nominal offsets equivalent to not more than 2 quarter-bends.

See section E 346.10 for bends in conduit.

TABLE 3

COMBINATION OF CONDUCTORS

(See sections E 346.06 and E 348.06)

For groups or combination of conductors not included in table 1, chapter E 900, it is recommended that the conduit or tubing be of such size that the sum of the cross-sectional areas of the individual conductors will not be more than the percentage of the interior cross-sectional area of the conduit or tubing shown in the following table:

PER CENT AREA OF CONDUIT OR TUBING

	Number of Conductors				
	1	2	3	4	Over 4
*Conductors (not lead covered)	53	31	43	40	40
Lead covered conductors	55	30	40	38	35
**For rewiring existing raceways for increased load where it is impracticable to increase the size of the raceway due to structural conditions	60	40	50	50	50

Note 1. See note to table 5 for size of conduit or tubing for combinations of conductors not shown in table 1.

Note 2. For carrying capacity of more than 3 conductors in a conduit or tubing, see tables E 310.12 through E 310.15, note 8.

Note 3. See tables 4 through 7, chapter E 900, for dimensions of conductors, conduit and tubing.

**Note 4.* Use actual dimensions of wire or cable unless it is smaller than dimension of RW. Use dimension of RW as minimum dimension.

***Note 5.* For rewiring, figure dimension of wire or cable actually used.

Note 6. For exposed runs of service conduit or tubing not over 30 feet in length, the size of conduit or tubing may be determined as permitted for rewiring.

Note 7. For multi-conductor cables use actual cable cross-section areas. Conductor numbers at head of columns shall be taken as numbers of cables.

Note 8. For bare wires, use actual area from table 8.

Tables 4 through 7. Chapter E 900. Tables 4 through 7 give the nominal size of conductors and conduit or tubing recommended for use in computing size of conduit or tubing for various combinations of conductors. The dimensions represent average conditions only, and while variations will be found in dimensions of conductors and conduit of different manufacture, these variations will not affect the computation.

TABLE 4

DIMENSIONS AND PER CENT AREA OF CONDUIT AND OF TUBING

Areas of conduit or tubing for the combinations of wires permitted in table 3, chapter E 900

Trade Size	Internal Diameter Inches	Area—Square Inches											
		Total 100%	Not Lead Covered				Lead Covered					Rewiring Not Lead Covered		
			1 Cond. 53%	2 Cond. 31%	3 Cond. 43%	4 Cond. and Over 40%	1 Cond. 55%	2 Cond. 30%	3 Cond. 40%	4 Cond. 38%	Over 4 Cond. 35%	1 Cond. 60%	2 Cond. 40%	3 Cond. and Over 50%
½	.622	.30	.16	.09	.13	.12	.17	.09	.12	.11	.11	.18	.12	.15
¾	.824	.53	.28	.16	.23	.21	.29	.16	.21	.20	.19	.32	.21	.27
1	1.049	.86	.46	.27	.37	.34	.47	.26	.34	.33	.30	.52	.34	.43
1¼	1.380	1.50	.80	.47	.65	.60	.83	.45	.60	.57	.53	.90	.60	.75
1½	1.610	2.04	1.08	.63	.88	.82	1.12	.61	.82	.78	.71	1.22	.82	1.02
2	2.067	3.36	1.78	1.04	1.44	1.34	1.85	1.01	1.34	1.28	1.18	2.02	1.34	1.68
2½	2.469	4.79	2.54	1.48	2.06	1.92	2.63	1.44	1.92	1.82	1.68	2.87	1.92	2.40
3	3.068	7.38	3.91	2.29	3.17	2.95	4.06	2.21	2.95	2.80	2.58	4.43	2.95	3.69
3½	3.548	9.90	5.25	3.07	4.26	3.96	5.44	2.97	3.96	3.76	3.47	5.94	3.96	4.95
4	4.026	12.72	6.74	3.94	5.47	5.09	7.00	3.82	5.09	4.83	4.45	7.63	5.09	6.36
5	5.047	20.00	10.60	6.20	8.60	8.00	11.00	6.00	8.00	7.60	7.00	12.00	8.00	10.00
6	6.065	28.89	15.31	8.96	12.42	11.56	15.89	8.67	11.56	10.98	10.11	17.33	11.56	14.45

TABLE 5

DIMENSIONS OF RUBBER-COVERED AND THERMOPLASTIC-COVERED CONDUCTORS

Size AWG MCM	Types RF-2, RFH-2, R, RH, RHH, RHW, RH-RW, RW, THW		Types TF, T, TW, RU**, RUH**, RUW	
	Approx. Diam. Inches	Approx. Area Sq. Ins.	Approx. Diam. Inches	Approx. Area Sq. Ins.
18	.146	.0167	.106	.0088
16	.158	.0196	.118	.0109
14	2/64 in. .171	.0230	.131	.0135
14	3/64 in. .204*	.0327*		
12	2/64 in. .188	.0278	.148	.0172
12	3/64 in. .221*	.0384*		
10	.242	.0460	.168	.0224
8	.311	.0760	.228	.0408
6	.397	.1238	.323	.0819
4	.452	.1605	.372	.1087
3	.481	.1817	.401	.1263
2	.513	.2067	.433	.1473
1	.588	.2715	.508	.2027
0	.629	.3107	.549	.2367
00	.675	.3578	.595	.2781
000	.727	.4151	.647	.3288
0000	.785	.4840	.705	.3904
250	.868	.5917	.788	.4877
300	.933	.6837	.843	.5581
350	.985	.7620	.895	.6291
400	1.032	.8365	.942	.6969
500	1.119	.9834	1.029	.8316
600	1.238	1.1940	1.143	1.0261
700	1.304	1.3355	1.214	1.1575
750	1.339	1.4082	1.249	1.2252
800	1.372	1.4784	1.282	1.2908
900	1.435	1.6173	1.345	1.4208
1000	1.494	1.7531	1.404	1.5482
1250	1.676	2.2062	1.577	1.9532
1500	1.801	2.5475	1.702	2.2748
1750	1.916	2.8895	1.817	2.5930
2000	2.021	3.2079	1.922	2.9013

*The dimensions of types RW, RHH and THW wire. Also, these dimensions to be used for new work in computing size of conduit or tubing for combinations of wires not shown in table 1, chapter E 900.

**No. 14 to No. 2.

No. 18 to No. 8, solid; No. 6 and larger, stranded.

The dimensions of rubber-covered conductors in column 3 of this table are to be used in computing the size of conduit or tubing for new work for combinations not shown in table 1. The dimensions in the last column of this table may be used only for rewiring existing raceways.

TABLE 6

DIMENSIONS OF LEAD-COVERED CONDUCTORS

Types RL, RHL, and RUL

Size AWG MCM	Single Conductor		Two Conductor		Three Conductor	
	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.
14	.28	.062	.28 x .47	.115	.59	.273
12	.29	.066	.31 x .54	.146	.62	.301
10	.35	.096	.35 x .59	.180	.68	.363
8	.41	.132	.41 x .71	.255	.82	.528
6	.49	.188	.49 x .86	.369	.97	.738
4	.55	.237	.54 x .96	.457	1.08	.916
2	.60	.283	.61 x 1.08	.578	1.21	1.146
1	.67	.352	.70 x 1.23	.756	1.38	1.49
0	.71	.396	.74 x 1.32	.859	1.47	1.70
00	.76	.454	.79 x 1.41	.980	1.57	1.94
000	.81	.515	.84 x 1.52	1.123	1.69	2.24
0000	.87	.593	.90 x 1.64	1.302	1.85	2.68
250	.98	.754	----------	----------	2.02	3.20
300	1.04	.85	----------	----------	2.15	3.62
350	1.10	.95	----------	----------	2.26	4.02
400	1.14	1.02	----------	----------	2.40	4.52
500	1.23	1.18	----------	----------	2.59	5.28

Note: No. 14 to No. 8, solid conductors: No. 6 and larger, stranded conductors. Data for 2/64-inch insulation not yet compiled.

TABLE 7

DIMENSIONS OF ASBESTOS-VARNISHED-CAMBRIC INSULATED CONDUCTORS

Types AVA, AVB, and AVL

Size AWG MCM	Type AVA		Type AVB		Type AVL	
	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.
14	.245	.047	.205	.033	.320	.080
12	.265	.055	.225	.040	.340	.091
10	.285	.064	.245	.047	.360	.102
8	.310	.075	.270	.057	.390	.119
6	.395	.122	.345	.094	.430	.145
4	.445	.155	.395	.123	.480	.181
2	.505	.200	.460	.166	.570	.255
1	.585	.268	.540	.229	.620	.300
0	.625	.307	.580	.264	.660	.341
00	.670	.353	.625	.307	.705	.390
000	.720	.406	.675	.358	.755	.447
0000	.780	.478	.735	.425	.815	.521
250	.885	.616	.855	.572	.955	.715
300	.940	.692	.910	.649	1.010	.800
350	.995	.778	.965	.731	1.060	.885
400	1.040	.850	1.010	.800	1.105	.960
500	1.125	.995	1.095	.945	1.190	1.118
550	1.165	1.065	1.135	1.01	1.265	1.26
600	1.205	1.140	1.175	1.09	1.305	1.34
650	1.240	1.21	1.210	1.15	1.340	1.41
700	1.275	1.28	1.245	1.22	1.375	1.49
750	1.310	1.35	1.280	1.29	1.410	1.57
800	1.345	1.42	1.315	1.36	1.440	1.63
850	1.375	1.49	1.345	1.43	1.470	1.70
900	1.405	1.55	1.375	1.49	1.505	1.78
950	1.435	1.62	1.405	1.55	1.535	1.85
1000	1.465	1.69	1.435	1.62	1.565	1.93

Note: No. 14 to No. 8, solid, No. 6 and larger, stranded; except AVL where all sizes are stranded.

VARNISHED-CAMBRIC INSULATED CONDUCTORS
Type V

The insulation thickness for varnished-cambric conductors, type V is the same as for rubber-covered conductors, type R, except for Nos. 14 and 12 which have 3/64-inch insulation for varnished-cambric and 2/64-inch insulation for rubber-covered conductors and for No. 8 which has 3/64-inch insulation for varnished-cambric, and 4/64-inch insulation for rubber-covered conductors. See table E 310.02 (2). Tables 1 and 2 may, therefore, be used for the number of varnished-cambric insulated conductors in a conduit or tubing.

TABLE 8

PROPERTIES OF CONDUCTORS

Size AWG	Area Cir. Mils.	Concentric Lay Stranded Conductors		Bare Conductors		D. C. Resistance Ohms/M Ft. at 25°C. 77°F.		
		No. Wires	Diam. Each Wire Inches	Diam. Inches	*Area Sq. Inches	Copper		Aluminum
						Bare Cond.	Tin'd. Cond.	
18	1624	Solid	.0403	.0403	.0013	6.510	6.77	10.9
16	2583	Solid	.0508	.0508	.0020	4.094	4.25	6.85
14	4107	Solid	.0641	.0641	.0032	2.575	2.68	4.31
12	6530	Solid	.0808	.0808	.0051	1.619	1.69	2.71
10	10380	Solid	.1019	.1019	.0081	1.018	1.06	1.70
8	16510	Solid	.1285	.1285	.0130	.641	.660	1.07
6	26250	7	.0612	.184	.027	.410	.426	.674
4	41740	7	.0772	.232	.042	.259	.269	.423
3	52640	7	.0867	.260	.053	.205	.213	.336
2	66370	7	.0974	.292	.067	.162	.169	.266
1	83690	19	.0664	.332	.087	.129	.134	.211
0	105500	19	.0745	.373	.109	.102	.106	.168
00	133100	19	.0837	.418	.137	.0811	.0844	.134
000	167800	19	.0940	.470	.173	.0642	.0668	.105
0000	211600	19	.1055	.528	.219	.0509	.0524	.0837
	250000	37	.0822	.575	.260	.0431	.0444	.0708
	300000	37	.0900	.630	.312	.0360	.0371	.0590
	350000	37	.0973	.681	.364	.0308	.0318	.0506
	400000	37	.1040	.728	.416	.0270	.0278	.0443
	500000	37	.1162	.814	.520	.0216	.0225	.0354
	600000	61	.0992	.893	.626	.0180	.0185	.0295
	700000	61	.1071	.964	.730	.0154	.0159	.0253
	750000	61	.1109	.998	.782	.0144	.0148	.0236
	800000	61	.1145	1.031	.835	.0135	.0139	.0221
	900000	61	.1215	1.093	.938	.0120	.0124	.0197
	1000000	61	.1280	1.152	1.042	.0108	.0111	.0176
	1250000	91	.1172	1.289	1.305	.00864	.00890	.0142
	1500000	91	.1284	1.412	1.566	.00719	.00740	.0118
	1750000	127	.1174	1.526	1.829	.00617	.00636	.0101
	2000000	127	.1255	1.631	2.089	.00539	.00555	.00884

*Area given is that of a circle having a diameter equal to the overall diameter of a stranded conductor.

The values given in the table are those given in Circular 31 of the National Bureau of Standards except that those shown in the 8th column are those given in Specification B33 of the American Society for Testing Materials.

The resistance values given in the last three columns are applicable only to direct current. When conductors larger than No. 4/0 are used with alternating current the multiplying factors in table 9, chapter E 900 should be used to compensate for skin effect.

TABLE 9

MULTIPLYING FACTORS FOR CONVERTING D. C. RESISTANCE TO 60 CYCLE A. C. RESISTANCE

Size	Multiplying Factor			
	For Non-metallic Sheathed Cables in Air or Non-metallic Conduit		For Metallic Sheathed Cables or All Cables in Metallic Raceways	
	Copper	Aluminum	Copper	Aluminum
Up to 3 AWG	1.	1.	1.	1.
2	1.	1.	1.01	1.00
1	1.	1.	1.01	1.00
0	1.001	1.000	1.02	1.00
00	1.001	1.001	1.03	1.00
000	1.002	1.001	1.04	1.01
0000	1.004	1.002	1.05	1.01
250000 CM	1.005	1.002	1.06	1.02
300000 CM	1.006	1.003	1.07	1.02
350000 CM	1.009	1.004	1.08	1.03
400000 CM	1.011	1.005	1.10	1.04
500000 CM	1.018	1.007	1.13	1.06
600000 CM	1.025	1.010	1.16	1.08
700000 CM	1.034	1.013	1.19	1.11
750000 CM	1.039	1.015	1.21	1.12
800000 CM	1.044	1.017	1.22	1.14
1000000 CM	1.067	1.026	1.30	1.19
1250000 CM	1.102	1.040	1.41	1.27
1500000 CM	1.142	1.058	1.53	1.36
1750000 CM	1.185	1.079	1.67	1.46
2000000 CM	1.233	1.100	1.82	1.56

B. EXAMPLES

Selection of Conductors. In the following examples, the size of conductor has been selected on the basis of the allowable current-carrying capacities tabulated in the second column of table E 310.12. If other types of insulated conductors are used, or if the conductors are run open, or with more than three conductors in a raceway, the size of conductor may vary from those shown. Tables E 310.12 through E 310.15 and notes thereto should be consulted in selecting the size of conductor for a particular installation.

Voltage. For uniform application of the provisions of chapters E 210, E 215 and E 220 a nominal voltage of 115 and 230 volts shall be used in computing the ampere load on the conductor.

Fractions of an Ampere. Where the computations result in a fraction of an ampere, such fractions may be dropped.

Ranges. For the computation of the range loads in these examples column A of table E 220.05 has been used. For optional methods, see columns B and C of table E 220.05.

Example No. 1. Single Family Dwelling

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic, and open porches. It has a 12 kw range.

Computed Load (see E 220.04)

General Lighting Load:

1500 sq. ft. at 3 watts per sq. ft. = 4500 watts.

Minimum Number of Branch Circuits Required (see E 220.03)

General Lighting Load:

4500 ÷ 115 = 39.1 amperes; or three 15 ampere 2-wire circuits; or two 20 ampere 2-wire circuits.

Small Appliance Load: Two 2-wire 20 ampere circuits (E 220.03 (2))

Minimum Size Feeders Required (see E 220.04)

Computed Load

General Lighting	4500 watts
Small Appl. Load	3000 watts
Total (without range)	7500 watts
3000 watts at 100%	3000 watts
7500 — 3000 = 4500 watts at 35%	1575 watts
Net computed (without range)	4575 watts
Range Load (see table E 220.05)	8000 watts
Net computed (with range)	12,575 watts

For 115/230 volt 3-wire system feeders, 12,575 ÷ 230 = 55 amperes.

Therefore, feeder size for total load may be selected on basis of 55 ampere load (see E 215.02).

Net computed load exceeds 10 kw so service conductors shall be 100 amperes (see E 230.041 Exception No. 1).

Example No. 1 (a). Single Family Dwelling

Same conditions as Example No. 1, plus addition of one 6 ampere 230 volt room air conditioning unit and three 12 ampere 115 volt room air conditioning units. See E 422.39, E 422.40 and E 422.41.

From Example No. 1, feeder current is 55 amperes (3-wire, 230 volt)

Line A	Neutral	Line B
55		55 amperes from Example No. 1
6		6 one 230 volt air cond. motor
12		12 two 115 volt air cond. motors
--		12 one 115 volt air cond. motor
3		3 25% of largest motor (E 430.024)
—		—
76		88 amperes per line

Therefore, feeder size for total load may be selected on basis of 88 ampere load.

For feeder overcurrent protection see E 215.04 and E 430.063.

Example No. 1 (b). Single Family Dwelling

Optional Calculation for One-Family Dwelling (E 220.07)

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic and open porches. It has a 12 kw range, a 2.5 kw water heater, a 1.2 kw dishwasher, 9 kw of electric space heating installed in five rooms, a 4.5 kw clothes dryer, and a 6 amp. 230 volt room air conditioning unit.

Air conditioner kw is 6 × 230 ÷ 1000 = 1.38 kw

1.38 kw is less than the connected load of 9 kw of space heating; therefore, the air conditioner load need not be included in the service calculation (see E 220.04 (12)).

1500 sq. ft. at 3 watts	4.5 kw
Two 20 amp. appliance outlet circuits at 1500 watts each	3.0 kw
Range (at nameplate rating)	12.0 kw
Water heater	2.5 kw
Dishwasher	1.2 kw
Space heating	9.0 kw
Clothes dryer	4.5 kw
	36.7 kw

First 10 kw at 100% = 10.00 kw
Remainder at 40% (26.7 kw × .4) = 10.68 kw

Calculated load for service size 20.68 kw = 20,680 watts
20,680 ÷ 230 = 90 amperes
Therefore, this dwelling may be served by a 100 ampere service.

Example No. 1 (c). Single Family Dwelling

Optional Calculation for One-Family Dwelling (See E 220.07)

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic and open porches. It has three-20 ampere small appliance circuits, two 4 kw wall-mounted ovens, one 5.1 kw counter-mounted cooking unit, a 4.5 kw water heater, a 1.2 kw dishwasher, a 4.2 kw combination clothes washer and dryer, six-7 ampere 230 volt room air conditioning units and a 1.5 kw permanently installed bathroom space heater.

Air Conditioning kw Calculation

Total amperes 6 × 7 = 42.00 amperes
25% of largest motor .25 × 7 = 1.75 amperes
43.75 amperes
43.75 × 230 ÷ 1000 = 10.1 kw of air conditioner load

Load Included at 100%

Air conditioning	10.1 kw
Space heater (omit, see E 220.04 (12))	

Other Load

1500 sq. ft. at 3 watts	4.5
Three 20 amp. small appliance circuits at 1500 watts	4.5
2 ovens	8.
1 cooking unit	5.1
Water heater	4.5
Dishwasher	1.2
Washer/Dryer	4.2
Total other load	32.0
1st 10 kw at 100%	10.0 kw
Remainder at 40% (22 kw × .4)	8.8 kw
Total calculated load	28.9 kw = 28,900 watts

28,900 ÷ 230 = 126 amperes (service rating)

Example No. 2. Small Roadside Fruitstand With No Show Windows

A small roadside fruitstand with no show windows has a floor area of 150 square feet. The electrical load consists of general lighting and a 1000 watt floodlight. There are no other outlets.

Computed Load (E 220.04)

*General Lighting

150 sq. ft. at 3 watts/sq. ft. × 1.25 = 562 watts
(3 watts/sq. ft. for stores)
562 watts ÷ 115 = 4.88 amperes
One 15 ampere 2-wire branch circuit required (E 220.03)

Minimum Size Service Conductor Required (E 230.041 Exception No. 1)

Computed load ---------- 562 watts
Floodlight load ---------- 1000 watts

Total load ---------- 1562 watts

1562 ÷ 115 = 13.6 amperes

Use No. 8 service conductor (E 230.041 Exception No. 1)
Use a 30 ampere service switch or breaker (E 230.071)

Example No. 3. Store Building

A store 50 feet by 60 feet, or 3,000 square feet, has 30 feet of show window.

Computed Load (E 220.04)

*General lighting load:

3,000 square feet at 3 watts per square foot × 1.25 -- 11,250 watts

**Show window lighting load:

30 feet of 200 watts per foot ---------- 6,000 watts

Minimum Number of Branch Circuits Required (E 220.03)

***General lighting load: 11,250 ÷ 230 = 49 amperes for 3-wire, 115/230 volts; or 98 amperes for 2-wire, 115 volts:

Three 30 ampere, 2-wire; and one 15 ampere, 2-wire circuits; or
Five 20 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire, and three 15 ampere, 2-wire circuits; or
Seven 15 ampere, 2-wire, circuits; or
Three 15 ampere, 3-wire, and one 15 ampere, 2-wire circuits.

Special lighting load (show window): (E 220.02 Exception No. 2 and E 220.04 (2)): 6,000 ÷ 230 = 26 amperes for 3-wire, 115/230 volts; or 52 amperes for 2-wire, 115 volts:

Four 15 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire circuits, or
Two 15 ampere, 3-wire circuits.

Minimum Size Feeders (or Service Conductors) Required (E 215.02):

For 115/230 volt, 3-wire system:
Ampere load: 49 plus 26 = 75 amperes. (E 220.02):
Size of each feeder, No. 3

For 115 volt system:
Ampere load: 98 plus 52 = 150 amperes (E 220.02):
Size of each feeder, No. 3/0

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* The above examples assume that the entire general lighting load is likely to be used for long periods of time and the load is therefore increased by 25% in accordance with E 220.02. The 25% increase is not applicable to any portion of the load not used for long periods.

** If show window load computed as per E 220.02, the unit load per outlet to be increased 25%.

*** The load on individual branch circuits not to exceed 80% of the branch circuit rating (E 210.23 (2)).

Example No. 4. Multi-Family Dwelling

Multi-family dwelling having a total floor area of 32,000 square feet with 40 apartments.

Meters in two banks of 20 each and individual sub-feeders to each apartment.

One-half of the apartments are equipped with electric ranges of not exceeding 12 kw each.

Area of each apartment is 800 square feet.

Computed Load for Each Apartment (Chapter E 220):

General lighting load:
800 square feet at 3 watts per square foot ---------2,400 watts
Special appliance load:
Electric range ----------8,000 watts

Minimum Number of Branch Circuits Required for Each Apartment (E 220.03):

General lighting load: 2,400 ÷ 115 = 21 amperes or two 15 ampere, 2-wire circuits; or two 20 ampere, 2-wire circuits.

Small appliance load: Two 2-wire circuits of No. 12 wire. (See E 220.03 (2)).

Range Circuit: 8,000 ÷ 230 = 34 amperes or a circuit of two No. 8's and one No. 10 as permitted by E 210.09 (3).

Minimum Size Sub-Feeder Required for Each Apartment (E 215.02):

Computed load (Chapter E 220):

General lighting load ----------	2,400 watts
Small appliance load, two 20 ampere circuits ---------	3,000 watts
Total computed load (without ranges) ----------	5,400 watts

Application of Demand Factor:

3,000 watts at 100% ----------	3,000 watts
2,400 watts at 35% ----------	840 watts
Net computed load (without ranges) ----------	3,840 watts
Range load ----------	8,000 watts
Net computed load (with ranges) ----------	11,840 watts

For 115/230 volt, 3-wire system (without ranges):
Net computed load, 3,840 ÷ 230 = 16.7 amperes.
Size of each sub-feeder (see E 215.02).

For 115/230 volt, 3-wire system (with ranges):
Net computed load, 11,840 ÷ 230 = 51.5 amperes.
Size of each ungrounded sub-feeder, No. 6.

Neutral Sub-Feeder:

Lighting and small appliance load ----------	3,840 watts
Range load, 8,000 watts at 70% (see E 220.04 (7)) ---	5,600 watts
Net computed load (neutral) ----------	9,440 watts

9,440 ÷ 230 = 41 amperes
Size of neutral sub-feeder, No. 6

Minimum Size Feeders Required from Service Equipment to Meter Bank (For 20 Apartments—10 with Ranges):

Total Computed Load:		
Lighting and small appliance load, 20 × 5,400	108,000	watts
Application of Demand Factor:		
3,000 watts at 100%	3,000	watts
105,000 watts at 35%	36,750	watts
Net computed lighting and small appliance load	39,750	watts
Range load, 10 ranges (less than 12 kw; Col. A, table E 220.05)	25,000	watts
Net computed load (with ranges)	64,750	watts

For 115/230 volt, 3-wire system:
Net computed load, 64,750 ÷ 230 = 282 amperes.
Size of each ungrounded feeder to each meter bank: 500,000 c.m.

Neutral Feeder:		
Lighting and small appliance load	39,750	watts
Range load: 25,000 watts at 70% (see E 220.04 (7))	17,500	watts
Computed load (neutral)	57,250	watts

57,250 ÷ 230 = 249 amperes.

Further Demand Factor (E 220.04 (7)):		
200 amperes at 100%	= 200	amperes
49 amperes at 70%	= 34	amperes
Net computed load (neutral)	234	amperes

Size of neutral feeder to each meter bank: 300,000 c.m.

Minimum Size Main Feeder (or Service Conductors) Required (For 40 Apartments—20 with Ranges):

Total computed load:		
Lighting and small appliance load, 40 × 5,400	216,000	watts
Application of Demand Factor:		
3,000 watts at 100%	3,000	watts
117,000 watts at 35%	40,950	watts
96,000 watts at 25%	24,000	watts
Net computed lighting and small appliance load	67,950	watts
Range load, 20 ranges (less than 12 kw, Col. A, table E 220.05)	35,000	watts
Net computed load	102,950	watts

For 115/230 volt, 3-wire system:
Net computed load, 102,950 ÷ 230 = 448 amperes.
Size of each ungrounded main feeder: 1,000,000 c.m.

Neutral Feeder:		
Lighting and small appliance load	67,950	watts
Range load, 35,000 watts at 70% (see E 220.04 (7))	24,500	watts
Computed load (neutral)	92,450	watts

92,450÷ 230 = 402 amperes.

Further Demand Factor (see E 220.04 (7)):
200 amperes at 100% = 200 amperes
202 amperes at 70% = 141 amperes

Net computed load (neutral) 341 amperes
Size of neutral main feeder: 600,000 c.m.
See tables E 310.12 through E 310.15, notes 8 and 12.

Example No. 5. Calculation of Neutral Feeder
(See E 220.04)

The following example illustrates the method of calculating size of neutral feeder for the computed load of a 5-wire, 2-phase system, where it is desired to modify the load in accordance with provisions of E 220.04.

An installation consisting of a computed load of 250 amperes connected between neutral feeder and each ungrounded feeder.

Neutral Feeder (maximum unbalance of load 250 amp. × 140% = 350 amperes):
200 amperes (first) at 100% = 200 amperes
150 amperes (excess) at 70% = 105 amperes

Computed load ---------- 305 amperes
Size of neutral feeder: 500,000 c.m.

Example No. 6. Maximum Demand for Range Loads

Table E 220.05, column A applies to ranges not over 12 kw. The application of Note 1 to ranges over 12 kw (and not over 21 kw) is illustrated in the following examples:

A. Ranges all of same rating.
Assume 24 ranges each rated 16 kw.
From Column A the maximum demand for 24 ranges of 12 kw rating is 39 kw.
16 kw exceeds 12 kw by 4.
5% × 4 = 20% (5% increase for each kw in excess of 12).
39 kw × 20% = 7.8 kw increase.
39 + 7.8 = 46.8 kw: value to be used in selection of feeders.

B. Ranges of unequal rating.
Assume 5 ranges each rated 11 kw.
2 ranges each rated 12 kw.
20 ranges each rated 13.5 kw.
3 ranges each rated 18 kw.
5 × 12 = 60 Use 12 kw for range rated less than 12.
2 × 12 = 24
20 × 13.5 = 270
3 × 18 = 54

408 kw
408 ÷ 30 = 13.6 kw (average to be used for computation)
From Column A the demand for 30 ranges of 12 kw rating is 15 + 30 = 45 kw.
13.6 exceeds 12 by 1.6 (use 2.).
5% × 2 = 10% (5% increase for each kw in excess of 12).
45 kw × 10% = 4.5 kw increase.
45 + 4.5 = 49.5 kw = value to be used in selection of feeders.

Example No. 7. Ranges on a 3-Phase System

(See E 220.04 (5))

Thirty ranges rated at 12 kw each are supplied by a 3-phase, 4-wire, 120/208-volt feeder, 10 ranges on each phase.

As there are 20 ranges connected to each ungrounded conductor, the load should be calculated on the basis of 20 ranges (or in case of unbalance, twice the maximum number between any two phase wires) since diversity applies only to the number of ranges connected to adjacent phases and not the total.

The current in any one conductor will be one-half the total watt load of two adjacent phases divided by the line-to-neutral voltage. In this case, 20 ranges, from table E 220.05, will have a total watt load of 35,000 watts for two phases; therefore, the current in the feeder conductor would be:

$$17{,}500 \div 120 = 146 \text{ amperes.}$$

On a 3-phase basis the load would be:

$$3 \times 17{,}500 = 52{,}500 \text{ watts.}$$

and the current in each feeder conductor—

$$\frac{52{,}500}{208 \times 1.73} = 146 \text{ amperes.}$$

Example No. 8. Motors, Conductors, and Overcurrent Protection

(See E 430.022, E 430.024, E 430.032 and E 430.052)

Determine the size of conductors, the motor-running overcurrent protection, the branch circuit protection, and the feeder protection, for one 25-h.p. squirrel-cage induction motor (full-voltage starting), and two 30-h.p. wound-rotor induction motors, on a 440-volt, 3-phase, 60-cycle supply.

Conductor Sizes

The full-load current of the 25-h.p. motor is 32 amperes (table E 430.150). A full-load current of 32 amperes $\times$ 1.25 (E 430.022) requires a No. 8, Type R, rubber-covered conductor (table E 310.12). The full-load current of the 30-h.p. motor is 39 amperes (table E 430.150). A full-load current of 39 amperes $\times$ 1.25 (E 430.022) requires a No. 6, Type R, rubber-covered conductor (table E 310.12).

The feeder conductor capacity will be 125 per cent of 39, plus 39, plus 32, or 120 amperes (E 430.024). In accordance with table E 310.12, this would require a No. 0, Type R, rubber-covered feeder.

Note: For Type R conductors run open in air, or for conductors with insulations other than Type R, see tables E 310.12 through E 310.15.

Overcurrent Protection

Running. The 25-h.p. motor, with full-load current of 32 amperes, must have running overcurrent protection of not over 40 amperes (Columns 2 and 3, table E 430.146). The 30-h.p. motor with full-load current of 39 amperes must have running overcurrent protection of not over 50 amperes (Columns 2 and 3, table E 430.146).

Branch Circuit. The branch circuit of the 25-h.p. motor must have branch-circuit overcurrent protection of not over 100 amperes (Column 4, table E 430.146). The branch circuit of the 30-h.p. motor must have branch-circuit overcurrent protection of not over 60 amperes (Column 7, table E 430.146).

Feeder Circuit. The rating of the branch-circuit fuse for a 25-h.p. squirrel-cage motor is 300 per cent of 32 amperes, or 96 amperes, which necessitates the use of a 100 ampere standard size fuse (table E 430.153); and for a 30-h.p. wound-rotor motor is 150 per cent of 39 amperes, or 59 amperes (table E 430.153). The rating of the feeder fuse is, therefore, 100 plus 39 plus 39 which equals 178 amperes, and a 200 ampere fuse is the maximum size which may be used (see E 430.062).

The setting of a motor-branch-circuit circuit-breaker for a 25-h.p. squirrel-cage motor is 250 per cent of 32 amperes or 80 amperes (table E 430.153); for a 30-h.p. wound-rotor motor is 150 per cent of 39 amperes or 59 amperes (table E 430.153). The maximum setting of a feeder circuit-breaker is 80 + 39 + 39 = 158 amperes (see E 430.062).