

Chapter E 900

TABLES AND EXAMPLES

A. TABLES

Where conduit nipples having a maximum length not to exceed 6 inches are installed between boxes, cabinets, gutters, switch cases and similar enclosures, the conductor fill in such nipples may be increased to not more than 60% of the internal cross-sectional area of the conduit, and note 8 of tables E 310.12 through E 310.15 does not apply to this condition.

TABLE 1
MAXIMUM NUMBER OF CONDUCTORS IN TRADE SIZES
OF CONDUIT OR TUBING
New Work or Rewiring—Types RF-2, RFH-2, R, RH, RW, RHH
NEW WORK—FEP, FEPB, RUH, RUW, T, TF, THEN, THW, THWN, TW
 Derating Factors for more than three conductors in raceways
 See note 8, tables E 310.12 through E 310.15
 (See section 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	6	8	15	21	34	50	76	103	132	208	
10	2	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	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	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 1A
MAXIMUM NUMBER OF CONDUCTORS IN TRADE SIZES
OF CONDUIT OR TUBING

Rewiring—Types TF, T, THW, TW, RUH, RUW

Derating Factors for more than three conductors in raceways
 See note 8, tables E 310.12 through E 310.15

(See section E 300.17, E 300.18, E 346.06 and E 348.06)

Rewiring

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % Conductor-fill, Table 3, Chapter 9, 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	13	24	38	68	93	152						
16	11	19	31	55	75	123	176	270				
14	5	10	16	29	40	65	93	143	192			
12	4	8	13	24	32	58	76	117	157	202		
10	4	6	11	19	26	43	61	95	127	163	257	
8	1	4	6	11	15	25	36	56	75	96	152	219
6	1	2	4	7	10	16	23	36	48	62	97	141
4	1	1	3	5	7	12	17	27	36	46	73	106
3	1	1	2	4	6	10	15	23	31	40	63	91
2	1	1	1	4	5	9	13	20	27	34	54	78
1	1	1	1	2	4	6	9	14	19	25	39	57
0		1	1	2	3	5	8	12	16	21	33	48
00		1	1	1	3	4	7	10	14	18	28	41
000			1	1	2	4	5	9	12	15	24	35
0000			1	1	1	3	5	7	10	13	20	29
250				1	1	2	4	6	8	10	16	23
300				1	1	2	3	5	7	9	14	20
350				1	1	1	3	4	6	8	12	18
400				1	1	1	2	4	5	7	11	16
500					1	1	1	3	4	6	9	14
600					1	1	1	3	4	5	7	11
700					1	1	1	2	3	4	7	10
750					1	1	1	2	3	4	6	9
800					1	1	1	1	3	4	6	9
900					1	1	1	1	2	3	5	8
1000					1	1	1	1	2	3	5	7
1250						1	1	1	1	2	4	6
1500							1	1	1	1	3	5
1750							1	1	1	1	3	4
2000								1	1	1	2	4

TABLE 1B
MAXIMUM NUMBER OF CONDUCTORS IN TRADE SIZES
OF CONDUIT OR TUBING

Rewiring—Types FEP, FEPB,* THHN, THWN

Derating Factors for more than three conductors in raceways
 See note 8, tables E 310.12 through E 310.15

(See section E 300.17, E 300.18, E 346.06 and E 348.06)

Rewiring

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % Conductor-fill, Table 3, Chapter 9, 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
14	13	24	39	69	94	154	220	252	---	---	---	---
12	10	18	29	51	70	114	164	160	215	276	---	---
10	6	11	18	32	44	72	104	160	93	125	160	252
8	3	6	10	19	26	42	60	93	76	98	154	222
6	1	4	6	11	15	25	37	58	76	98	154	222
4	1	2	4	7	9	16	22	35	47	60	94	136
3	1	1	3	6	8	13	19	29	39	51	80	116
2	1	1	3	5	7	11	16	25	33	43	67	97
1	1	1	1	3	5	8	12	18	25	32	50	72
0	---	1	1	3	4	7	10	15	21	27	42	61
00	---	1	1	2	3	6	8	13	17	22	35	51
000	---	1	1	1	3	5	7	11	14	18	29	42
0000	---	---	1	1	2	4	6	9	12	15	24	35
250	---	---	1	1	1	3	4	7	9	12	20	28
300	---	---	1	1	1	3	4	6	8	11	17	24
350	---	---	---	1	1	2	3	5	7	9	15	21
400	---	---	---	1	1	1	3	5	6	8	13	19
500	---	---	---	1	1	1	2	4	5	7	11	16

*Type FEPB sizes AWG No. 14-8, inclusive. Use table 1A for FEPB sizes larger than AWG No. 8.

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 Single Conductor Cables				Number of 2-Conductor Cables				Number of 3-Conductor Cables			
	1	2	3	4	1	2	3	4	1	2	3	4
14	1/2	3/4	3/4	1	3/4	1	1	1 1/4	3/4	1 1/4	1 1/2	1 1/2
12	1/2	3/4	3/4	1	3/4	1	1 1/4	1 1/4	1	1 1/4	1 1/2	2
10	1/2	3/4	1	1 1/4	1	1 1/4	1 1/4	1 1/2	1	1 1/2	2	2
8	1/2	1	1 1/4	1 1/2	1	1 1/4	1 1/2	2	1	2	2	2 1/2
6	3/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/2	2	2 1/2	1 1/4	2 1/2	3	3
4	3/4	1 1/4	1 1/2	1 1/2	1 1/4	2	2 1/2	2 1/2	1 1/2	3	3	3 1/2
3	3/4	1 1/4	1 1/2	2	1 1/4	2	2 1/2	3	1 1/2	3	3	3 1/2
2	1	1 1/4	1 1/2	2	1 1/4	2	2 1/2	3	1 1/2	3	3 1/2	4
1	1	1 1/2	2	2	1 1/2	2 1/2	3	3 1/2	2	3 1/2	4	5
0	1	2	2	2 1/2	2	2 1/2	3	3 1/2	2	4	5	5
00	1	2	2	2 1/2	2	3	3	3 1/2	2 1/2	5	5	5
000	1 1/4	2	2 1/2	2 1/2	2	3	3	4	2 1/2	5	5	6
0000	1 1/4	2 1/2	2 1/2	3	2 1/2	3	3 1/2	5	3	5	6	6
250	1 1/4	2 1/2	3	3	-----	-----	-----	-----	3	6	6	-----
300	1 1/2	3	3	3 1/2	-----	-----	-----	-----	3 1/2	6	6	-----
350	1 1/2	3	3	3 1/2	-----	-----	-----	-----	3 1/2	6	6	-----
400	1 1/2	3	3	3 1/2	-----	-----	-----	-----	3 1/2	6	6	-----
500	1 1/2	3	3 1/2	4	-----	-----	-----	-----	4	6	-----	-----
600	2	3 1/2	4	5	-----	-----	-----	-----	-----	-----	-----	-----
700	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
750	2	4	4	5	-----	-----	-----	-----	-----	-----	-----	-----
800	2	4	5	5	-----	-----	-----	-----	-----	-----	-----	-----
900	2 1/2	4	5	5	-----	-----	-----	-----	-----	-----	-----	-----
1000	2 1/2	5	5	6	-----	-----	-----	-----	-----	-----	-----	-----
1250	3	5	5	6	-----	-----	-----	-----	-----	-----	-----	-----
1500	3	5	6	6	-----	-----	-----	-----	-----	-----	-----	-----
1750	3	6	6	6	-----	-----	-----	-----	-----	-----	-----	-----
2000	3 1/2	6	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, E 346.11 and E 348.06)

For groups or combinations of conductors not included in table 1, chapter E 900, for new work, or tables 1, 1A or 1B chapter E 900, for rewiring, the conduit or tubing shall 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	40	40	40
Lead-covered conductors.....	55	30	40	38	35

For ampacity of more than three conductors in a conduit or tubing, see tables E 310. 12 through E 310.15, note 8.

See tables 4 through 8, chapter E 900 for dimensions of conductors, conduit and tubing.

Tables 4 through 8. Chapter E 900. Tables 4 through 8 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 conduits 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				
			1 Cond. 53%	2 Cond. 31%	3 Cond. and Over 40%	1 Cond. 55%	2 Cond. 30%	3 Cond. 40%	4 Cond. 38%	Over 4 Cond. 35%
1/2	.622	.30	.16	.09	.12	.17	.09	.12	.11	.11
3/4	.824	.53	.28	.16	.21	.29	.16	.21	.20	.19
1	1.049	.86	.46	.27	.34	.47	.26	.34	.33	.30
1 1/4	1.380	1.50	.80	.47	.60	.83	.45	.60	.57	.53
1 1/2	1.610	2.04	1.08	.63	.82	1.12	.61	.82	.78	.71
2	2.067	3.36	1.78	1.04	1.34	1.85	1.01	1.34	1.23	1.18
2 1/2	2.469	4.79	2.54	1.48	1.92	2.63	1.44	1.92	1.82	1.68
3	3.068	7.33	3.91	2.29	2.95	4.06	2.21	2.95	2.80	2.58
3 1/2	3.548	9.90	5.25	3.07	3.96	5.44	2.97	3.96	3.76	3.47
4	4.026	12.72	6.74	3.94	5.09	7.00	3.82	5.09	4.83	4.45
5	5.047	20.00	10.60	6.20	8.00	11.00	6.00	8.00	7.60	7.00
6	6.065	28.89	15.31	8.96	11.56	15.89	8.67	11.56	10.98	10.11

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		Types TF, T, THW, TW, RU,** RUH,** RUW**		Types THHN, THWN		Types FEP, FEPB			
	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.		
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8		Col. 9	
18 -----	.146	.0167	.196	.0088						
16 -----	.158	.0196	.115	.0109						
14 -----	2/64 in. .171	.0230	.131	.0135	.105	.0087	.105	.105	.0087	.0087
14 -----	3/64 in. .204*	.0327*								
14 -----			.162†	.0206†						
12 -----	2/64 in. .188	.0278	.145	.0172	.122	.0117	.121	.121	.0115	.0115
12 -----	3/64 in. .221*	.0384*								
12 -----			.179†	.0251†						
10 -----	.242	.0460	.168	.0224	.153	.0184	.142	.142	.0159	.0159
10 -----			.199†	.0311†						
8 -----			.288	.0408	.201	.0317	.189	.169	.0280	.0225
8 -----	.311	.0760	.259†	.0526†						
8 -----										
6 -----	.397	.1238	.323	.0819	.257	.0519	.244	.302	.0467	.0716
4 -----	.452	.1605	.372	.1087	.323	.0845	.292	.350	.0669	.0962
4 -----	.481	.1817	.401	.1263	.356	.0995	.320	.378	.0803	.1122
3 -----	.513	.2067	.433	.1473	.388	.1182	.352	.410	.0973	.1316
2 -----	.588	.2715	.508	.2027	.450	.1590				
2 -----										
0 -----	.629	.3107	.549	.2367	.491	.1893				
00 -----	.675	.3578	.595	.2781	.537	.2265				
000 -----	.727	.4151	.647	.3288	.588	.2715				
0000 -----	.785	.4840	.705	.3904	.646	.3278				

TABLE 5
DIMENSIONS OF RUBBER-COVERED AND THERMOPLASTIC-COVERED CONDUCTORS—Continued

Size AWG MCM	Types RF-2, RFH-2, R, RH, RHH, † RHW, ‡ RH-RW, RW		Types TF, T, THW, TW, RU,** RUH,** RUW**		Types THHN, THWN		Types FEP, FEPB	
	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9
250	.868	.5917	.788	.4877	.716	.4026		
300	.933	.6337	.843	.5581	.771	.4669		
350	.985	.7620	.895	.6291	.822	.5307		
400	1.032	.8365	.942	.6969	.869	.5931		
500	1.119	.9834	1.029	.8316	.955	.7163		
600	1.233	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 RHH, RH-RW, RHW, and RW 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.

†Dimensions of THW wire in sizes 14 to 8. No. 6 THW wire and larger is the same dimension as T wire.

‡Dimensions of RHH and RHW without outer covering are the same as THW.

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. For rewiring existing raceways, the areas in columns 3, 5, 7 and 9 are to be used.

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	2.63
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	.093	.320	.080
12	.265	.055	.225	.040	.340	.091
10	.285	.064	.245	.047	.360	.102
8	.310	.075	.270	.057	.380	.119
6	.395	.122	.345	.094	.430	.145
4	.445	.155	.395	.123	.480	.181
2	.505	.200	.450	.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.

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VARNISHED-CAMBRIC INSULATED CONDUCTORS

Type V

The insulation thickness for varnished-cambric conductors, type V, is the same as for rubber-covered conductors, type RH, except for Nos. 14 and 12 which have 3/64-inch insulation for varnished-cambric and 2/64 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 MCM	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		Alumi- num
						Bare Cond.	Tin'd. Cond.	
18	1,624	Solid	.0403	.0403	.0013	6.51	6.79	10.7
16	2,583	Solid	.0508	.0508	.0020	4.10	4.26	6.72
14	4,107	Solid	.0641	.0641	.0032	2.57	2.68	4.22
12	6,530	Solid	.0808	.0808	.0051	1.62	1.68	2.66
10	10,380	Solid	.1019	.1019	.0081	1.018	1.06	1.67
8	16,510	Solid	.1285	.1285	.0130	.6404	.659	1.05
6	26,250	7	.0612	.184	.027	.410	.427	.674
4	41,740	7	.0772	.232	.042	.259	.269	.424
3	52,640	7	.0887	.260	.053	.205	.213	.336
2	66,370	7	.0974	.292	.067	.162	.169	.266
1	83,690	19	.0664	.332	.087	.129	.134	.211
0	105,500	19	.0745	.373	.109	.102	.106	.168
00	133,100	19	.0837	.418	.137	.0811	.0843	.133
000	167,800	19	.0940	.470	.173	.0642	.0668	.105
0000	211,600	19	.1055	.528	.219	.0509	.0525	.836
250	250,000	37	.0822	.575	.260	.0431	.0449	.0708
300	300,000	37	.0900	.630	.312	.0360	.0374	.0590
350	350,000	37	.0973	.681	.364	.0308	.0320	.0505
400	400,000	37	.1040	.728	.416	.0270	.0278	.0442
500	500,000	37	.1162	.814	.520	.0216	.0222	.0354
600	600,000	61	.0992	.893	.626	.0180	.0187	.0295
700	700,000	61	.1071	.964	.730	.0154	.0159	.0253
750	750,000	61	.1109	.998	.782	.0144	.0148	.0236
800	800,000	61	.1145	1.031	.835	.0135	.0139	.0221
900	900,000	61	.1215	1.093	.938	.0120	.0123	.0197
1000	1,000,000	61	.1280	1.152	1.042	.0108	.0111	.0177
1250	1,250,000	91	.1172	1.239	1.305	.00863	.00888	.0142
1500	1,500,000	91	.1284	1.412	1.566	.00719	.00740	.0118
1750	1,750,000	127	.1174	1.526	1.829	.00616	.00634	.0101
2000	2,000,000	127	.1255	1.631	2.089	.00539	.00555	.00885

*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 3th column are those given in Specification B33 of the American Society for Testing and 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 Nonmetallic Sheathed Cables in Air or Nonmetallic 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
250 MCM.....	1.005	1.002	1.06	1.02
300 MCM.....	1.006	1.003	1.07	1.02
350 MCM.....	1.009	1.004	1.08	1.03
400 MCM.....	1.011	1.005	1.10	1.04
500 MCM.....	1.018	1.007	1.13	1.06
600 MCM.....	1.025	1.010	1.16	1.08
700 MCM.....	1.034	1.013	1.19	1.11
750 MCM.....	1.039	1.015	1.21	1.12
800 MCM.....	1.044	1.017	1.22	1.14
1000 MCM.....	1.067	1.026	1.30	1.19
1250 MCM.....	1.102	1.040	1.41	1.27
1500 MCM.....	1.142	1.058	1.53	1.36
1750 MCM.....	1.185	1.079	1.67	1.46
2000 MCM.....	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 3 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:

$4500 \div 115 = 39.1$ 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, $12,575 \div 230 = 55$ amperes. Therefore, feeder size for total load may be selected on basis of 55 ampere load (see E 215.02).

The service conductors shall be 100 ampere (see E 230.041(1) 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 chapter E 422, Part F.

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 1,500 square feet 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 with separate controls in each room, a 4.5 KW clothes dryer, and a 6 amp. 230 volt room air conditioning unit.

Air conditioner kw is $6 \times 230 \div 1000 = 1.38$ 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 \times .4) = 10.68 kw

Calculated load for service size 20.68 kw = 20,680 watts
 $20,680 \div 230 = 90$ 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 $6 \times 7 = 42.00$ amperes
 25% of largest motor $.25 \times 7 = 1.75$ amperes
 43.75 amperes

$43.75 \times 230 \div 1000 = 10.1$ 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 \times .4) 8.8 kw

Total calculated load 28.9 kw = 28,900 watts
 $28,900 \div 230 = 126$ 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. \times 1.25 = 562 watts

(3 watts/sq. ft. for stores)

562 watts \div 115 = 4.88 amperes

One 15 ampere 2-wire branch circuit required (E 220.03)

Minimum Size Service Conductor Required (E 230.041(2) Exception No. 2).

Computed load ----- 562 watts

Floodlight load ----- 1000 watts

Total load ----- 1562 watts

1562 \div 115 = 13.6 amperes

Use No. 8 service conductor (E 230.041(2) Exception No. 2).

Use a 30 ampere service switch or breaker (E 230.071(1) (b) Exception No. 2).

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 220.02)

***General lighting load:**

3,000 square feet at 3 watts per square foot \times 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 \div 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(5) (b) Exception No. 2): 6,000 \div 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 220.04) :

Size of each feeder, No. 3

For 115 volt system:

Ampere load: 98 plus 52 = 150 amperes (E 220.04) :

Size of each feeder, No. 3/0

* 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 each general lighting branch circuit not to exceed 80% of the branch circuit rating (subsection 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: $2,400 \div 115 = 21$ 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: $8,000 \div 230 = 34$ amperes or a circuit of two No. 8s and one No. 10 as permitted by E 210.19 (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, $3,840 \div 230 = 16.7$ amperes.

Size of each sub-feeder (see E 215.02).

For 115/230 volt, 3-wire system (with ranges):

Net computed load, $11,840 \div 230 = 51.5$ 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 (5)) --5,600 watts

Net computed load (neutral) -----9,440 watts

$9,440 \div 230 = 41$ 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, $20 \times 5,400$	-----108,000 watts
Application of Demand Factor:	
3,000 watts at 100%	----- 3,000 watts
105,000 watts at 35%	----- 36,750 watts
<hr/>	
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
<hr/>	
Net computed load (with ranges)	----- 64,750 watts
For 115/230 volt, 3-wire system:	
Net computed load, $64,750 \div 230 = 282$ 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 (5))	----- 17,500 watts
<hr/>	
Computed load (neutral)	----- 57,250 watts
$57,250 \div 230 = 249$ amperes.	
Further Demand Factor (E 220.04 (5)):	
200 amperes at 100%	= 200 amperes
49 amperes at 70%	= 34 amperes
<hr/>	
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, $40 \times 5,400$	-----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
<hr/>	
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
<hr/>	
Net computed load	-----102,950 watts
For 115/230 volt, 3-wire system:	
Net computed load, $102,950 \div 230 = 448$ 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 (5))	----- 24,500 watts
<hr/>	
Computed load (neutral)	----- 92,450 watts
$92,450 \div 230 = 402$ amperes.	

Further Demand Factor (see E 220.04 (5)):

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(5))

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. \times 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.

$5\% \times 4 = 20\%$ (5% increase for each kw in excess of 12).

$39 \text{ kw} \times 20\% = 7.8 \text{ kw increase.}$

$39 + 7.8 = 46.8 \text{ kw: value to be used in selection of feeders.}$

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.

$5 \times 12 = 60$ Use 12 kw for range rated less than 12.

$2 \times 12 = 24$

$20 \times 13.5 = 270$

$3 \times 18 = 54$

408 kw

$408 \div 30 = 13.6 \text{ kw (average to be used for computation)}$

From Column A the demand for 30 ranges of 12 kw rating is $15 + 30 = 45 \text{ kw.}$

13.6 exceeds 12 by 1.6 (use 2.).

$5\% \times 2 = 10\%$ (5% increase for each kw in excess of 12).

$45 \text{ kw} \times 10\% = 4.5 \text{ kw increase.}$

$45 + 4.5 = 49.5 \text{ kw = value to be used in selection of feeders.}$

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

(See E 220.04 (10))

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).