Chapter 9 Codes and Standards

9.1 Introduction

There are minimum performance requirements that should be incorporated in any design. The actual installation should meet or exceed these.

Standards are consensus documents typically developed by professional and technical societies. These typically become an American National Standards Institute (ANSI) standard.

Codes are standards that have been incorporated as law.

Industry practices are common techniques used by knowledgeable individuals.

9.2 NEC Synopsis

The National Electrical Code (NEC) is the standard for practical safeguarding of persons and equipment. The areas that involve calculations are the components that are most frequently on the professional exams. Articles are used as broad categories from NEC 2005. The specific section & table numbers may change between versions of the NEC.

General: Article 100

1) Definitions, workmanship, and responsibility are discussed in this section.

Identification of grounded conductors: Article 200

2) Grounding is bare, green, or green with yellow stripe.
3) Grounded, or neutral, is white or gray.
4) High-leg or wild-leg of a three-phase delta system with a center-tapped winding that is grounded must be orange. (Article 110)

Branch circuits: Article 210

1) Branch circuits are everything but motors.
2) General lighting can be on 15 A breakers.
3) The minimum number of 20 A branch circuits in a residence is 2 for small appliances, 1 for bath, and 1 for laundry.
4) Ground-fault protection is required in bathrooms, kitchens, garages, outside, and any other place that contact with a ground is possible.
5) Arc-fault breakers are required for bedrooms.

Feeders: Article 215

1) Ampacity = (1.25 * largest Full Load Amps) + sum of all other current loads.

Branch-circuit, feeder, and service calculations: Article 220

1) Demand factors and calculation requirements are covered.
2) Start in Part III and step through the applicable sections.

Overcurrent protection: Article 240

1) Overcurrent protection for specific equipment: Table 240.3
2) Protection of conductors shall be in accordance with ampacity from Table 310.16 ff

Grounding: Article 250

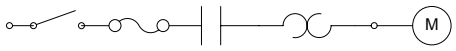
1) Sizing of grounding electrode conductor: Table 250.66
2) Sizing of equipment grounding conductor: Table 250.122
3) The maximum resistance of a grounding electrode according to Art 250.56: 25 Ω,
4) Conductor to be grounded - neutral or common: Art 250.26

Conductors for general wiring: Table 310.16 ff

1) Maximum capacity is shown in table at 30C
2) * AWG 14, 12, & 10 have maximum rating based on Art 240.4D, which is 5 A less than Table 310.16
3) Ampacity is rerated for different temperatures by the correction factors.
4) NM cable (Romex) is sized as 60C, regardless of insulation type
5) Alternate ampacity can be used under engineering supervision using Art 310.60D

Motors: Article 430

1) Motor full load current rating: Table 430.247 ff
2) Short circuit current = 6* full load current
3) Overload current = 1.5 * full load current
4) Maximum setting of motor branch circuit protection & ground fault protection: Table 430.52
5) Maximum locked-rotor current for selection of disconnecting means: Table 430.251
6) Locked rotor code letters for KVA per horsepower: Table 430.7
7) Environmental selection of motor controller enclosures: Table 430.91
8) Capacitor added to motor terminal: reduces total current from overload, so reduce size of overload only



Tables: Chapter 9

1) Conduit dimensions and fill
2) Insulated conductors nominal dimensions for AWG, diameter, area
3) Conductor properties including AWG, area, Ohms/kft
4) Cable resistance and reactance in conduit
5) Power source limitations

Examples: Annex D

1) Single family dwelling with appliance, heating, air conditioning
2) Store building
3) Industrial feeders
4) Multifamily dwelling with demand factors on single-phase and three-phase
5) Generator field control
6) Mobile home

9.3 Motor Installation Tables

This section lists excerpts from industry, national, and international standards. The excerpts are for illustration and educational purposes. There are often several related tables and information for other configurations and applications. In addition, the standards have added detail and information that applies to all these excerpts. Therefore, any application should refer to the standard, rather than the excerpts.

Standard	Organization	Application
National Electrical Code (NEC) NFPA 70-2005	National Fire Protection Association, Batterymarch Park, Quincy, MA	Electrical installations in occupancies
National Electrical Safety Code (NESC) IEEE C2-2002	Institute of Electrical & Electronics Engineers, New York, NewYork	Electrical supply stations, overhead, and underground lines.
Motors and Generators (MG1) NEMA MG1-2003	National Electrical Manufacturers Association	Performance of motors and generators

NEC 240.6(A) Standard Ampere Ratings for Fuses & Circuit Breakers

Amperes													
15	20	25	30	35	40	45	50	60	70	80	90	100	110
125	150	175	200	225	250	300	350	400	450	500	-	-	-
600	700	800	1000	1200	1600	2000	2500	3000	4000	5000	6000	-	-

Table 310.16 Allowable Ampacities of Insulated Conductors Rated 0 Through 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size AWG or kcmil	Temperature Rating of Conductor (See Table 310.13.)						Size AWG or kcmil
	60°C (140°F)	**75°C (167°F)**	**90°C (194°F)**	**60°C (140°F)**	**75°C (167°F)**	**90°C (194°F)**	
	Types TW, UF	**Types RHW, THHW, THW, THWN, XHHW, USE, ZW**	**Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2**	**Types TW, UF**	**Types RHW, THHW, THW, THWN, XHHW, USE**	**Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2**	
	COPPER			**ALUMINUM OR COPPER-CLAD ALUM**			
18	—	—	14	—	—	—	—
16	—	—	18	—	—	—	—
14*	20	20	25	—	—	—	—
12*	25	25	30	20	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	560	665	750	470	560	630	2000
CORRECTION FACTORS							
Ambient Temp. (°C)	**For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities shown above by the appropriate factor shown below.**						**Ambient Temp. (°F)**
21–25	1.08	1.05	1.04	1.08	1.05	1.04	70–77
26–30	1.00	1.00	1.00	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	—	0.58	0.71	132–140
61–70	—	0.33	0.58	—	0.33	0.58	141–158

71–80	—	—	0.41	—	—	0.41	159–176

* See 240.4(D).

Table 310.15(B)(2)(a) **Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable**

Number of Current-Carrying Conductors	Percent of Values in Tables 310.16 through 310.19 as Adjusted for Ambient Temperature if Necessary
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

Table 310.15(B)(6) **Conductor Types and Sizes for 120/240-Volt, 3-Wire, Single-Phase Dwelling Services and Feeders.**

Conductor Types RHH, RHW, RHW-2, THHN, THHW, THW, THW-2, THWN, THWN-2, XHHW, XHHW-2, SE, USE, USE-2

Conductor (AWG or kcmil)		
Copper	Aluminum or Copper-Clad Aluminum	Service or Feeder Rating (Amperes)
4	2	100
3	1	110
2	1/0	125
1	2/0	150
1/0	3/0	175
2/0	4/0	200
3/0	250	225
4/0	300	250
250	350	300
350	500	350
400	600	400

General, 430.1 through 430.18	Part I
Motor Circuit Conductors, 430.21 through 430.29	Part II
Motor and Branch-Circuit Overload Protection, 430.31 through 430.44	Part III
Motor Branch-Circuit Short-Circuit and Ground-Fault Protection, 430.51 through 430.58	Part IV
Motor Feeder Short-Circuit and Ground-Fault Protection, 430.61 through 430.63	Part V
Motor Control Circuits, 430.71 through 430.74	Part VI
Motor Controllers, 430.81 through 430.91	Part VII
Motor Control Centers, 430.92 through 430.98	Part VIII
Disconnecting Means, 430.101 through 430.113	Part IX
Adjustable Speed Drive Systems, 430.120 through 430.128	Part X
Over 600 Volts, Nominal, 430.221 through 430.227	Part XI
Protection of Live Parts—All Voltages, 430.231 through 430.233	Part XII
Grounding—All Voltages, 430.241 through 430.245	Part XIII
Tables, Tables 430.247 through 430.251(B)	Part XIV

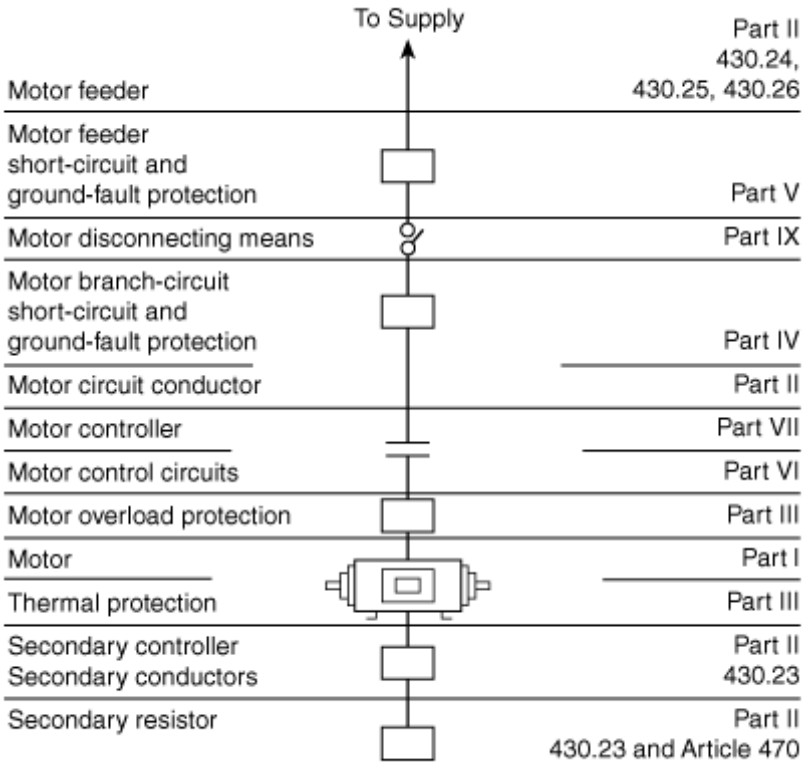


Figure 430.1 **Article 430 Contents**

Table 430.7(B) **Locked-Rotor Indicating Code Letters**

Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor	Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor
A	0–3.14	L	9.0–9.99
B	3.15–3.54	M	10.0–11.19
C	3.55–3.99	N	11.2–12.49
D	4.0–4.49	P	12.5–13.99
E	4.5–4.99	R	14.0–15.99
F	5.0–5.59	S	16.0–17.99
G	5.6–6.29	T	18.0–19.99
H	6.3–7.09	U	20.0–22.39
J	7.1–7.99	V	22.4 and up
K	8.0–8.99		

Table 430.52 **Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices**

Type of Motor	Percentage of Full-Load Current			
	Non-time Delay Fuse	Dual Element (Time-Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
Single-phase motors	300	175	800	250
AC polyphase motors other than wound-rotor				
Squirrel cage other than Design B energy-efficient	300	175	800	250
Design B energy-efficient	300	175	1100	250
Synchronous	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

Table 430.91 **Motor Controller Enclosure Selection**

For Outdoor Use										
	Enclosure Type Number1									
Provides a Degree of Protection Against the Following Environmental Conditions	**3**	**3R**	**3S**	**3X**	**3RX**	**3SX**	**4**	**4X**	**6**	**6P**
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Rain, snow, and sleet	X	X	X	X	X	X	X	X	X	X
Sleet2	—	—	X	—	—	X	—	—	—	—
Windblown dust	X	—	X	X	—	X	X	X	X	X
Hosedown	—	—	—	—	—	—	X	X	X	X
Corrosive agents	—	—	—	X	X	X	—	X	—	X
Temporary submersion	—	—	—	—	—	—	—	—	X	X
Prolonged submersion	—	—	—	—	—	—	—	—	—	X

For Indoor Use										
	Enclosure Type Number1									
Provides a Degree of Protection Against the Following Environmental Conditions	**1**	**2**	**4**	**4X**	**5**	**6**	**6P**	**12**	**12K**	**13**
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing	—	X	X	X	X	X	X	X	X	X
Circulating dust, lint, fibers, and flyings	—	—	X	X	—	X	X	X	X	X
Settling airborne dust, lint, fibers, and flyings	—	—	X	X	X	X	X	X	X	X
Hosedown and splashing water	—	—	X	X	—	X	X	—	—	—
Oil and coolant seepage	—	—	—	—	—	—	—	X	X	X
Oil or coolant spraying and splashing	—	—	—	—	—	—	—	—	—	X
Corrosive agents	—	—	—	X	—	—	X	—	—	—
Temporary submersion	—	—	—	—	—	X	X	—	—	—
Prolonged submersion	—	—	—	—	—	—	X	—	—	—

1Enclosure type number shall be marked on the motor controller enclosure.
2Mechanism shall be operable when ice covered.
FPN: The term *raintight* is typically used in conjunction with Enclosure Types 3, 3S, 3SX, 3X, 4, 4X, 6, 6P. The term *rainproof* is typically used in conjunction with Enclosure Type 3R, 3RX. The term *watertight* is typically used in conjunction with Enclosure Types 4, 4X, 6, 6P. The term *driptight* is typically used in conjunction with Enclosure Types 2, 5, 12, 12K, 13. The term *dusttight* is typically used in conjunction with Enclosure Types 3, 3S, 3SX, 3X, 5, 12, 12K, 13.

Table 430.248 **Full-Load Currents in Amperes, Single-Phase Alternating-Current Motors**

Horse-power	115 Volts	200 Volts	208 Volts	230 Volts
1/6	4.4	2.5	2.4	2.2
¼	5.8	3.3	3.2	2.9
1/3	7.2	4.1	4.0	3.6
½	9.8	5.6	5.4	4.9
¾	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8.0
1½	20	11.5	11.0	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7½	80	46.0	44.0	40
10	100	57.5	55.0	50

Table 430.250 **Full-Load Current, Three-Phase Alternating-Current Motors**

	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)			
Horse-power	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 Volts	230 Volts	460 Volts	575 Volts	2300 Volts
½	4.4	2.5	2.4	2.2	1.1	0.9	—	—	—	—	—
¾	6.4	3.7	3.5	3.2	1.6	1.3	—	—	—	—	—
1	8.4	4.8	4.6	4.2	2.1	1.7	—	—	—	—	—
1½	12.0	6.9	6.6	6.0	3.0	2.4	—	—	—	—	—
2	13.6	7.8	7.5	6.8	3.4	2.7	—	—	—	—	—
3	—	11.0	10.6	9.6	4.8	3.9	—	—	—	—	—
5	—	17.5	16.7	15.2	7.6	6.1	—	—	—	—	—
7½	—	25.3	24.2	22	11	9	—	—	—	—	—
10	—	32.2	30.8	28	14	11	—	—	—	—	—
15	—	48.3	46.2	42	21	17	—	—	—	—	—
20	—	62.1	59.4	54	27	22	—	—	—	—	—
25	—	78.2	74.8	68	34	27	—	53	26	21	—
30	—	92	88	80	40	32	—	63	32	26	—
40	—	120	114	104	52	41	—	83	41	33	—
50	—	150	143	130	65	52	—	104	52	42	—
60	—	177	169	154	77	62	16	123	61	49	12
75	—	221	211	192	96	77	20	155	78	62	15
100	—	285	273	248	124	99	26	202	101	81	20
125	—	359	343	312	156	125	31	253	126	101	25
150	—	414	396	360	180	144	37	302	151	121	30
200		552	528	480	240	192	49	400	201	161	40
250	—	—	—	—	302	242	60	—	—	—	—
300	—	—	—	—	361	289	72	—	—	—	—
350	—	—	—	—	414	336	83	—	—	—	—
400	—	—	—	—	477	382	95	—	—	—	—
450	—	—	—	—	515	412	103	—	—	—	—
500	—	—	—	—	590	472	118	—	—	—	—

*For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

Table 430.251(A) **Conversion Table of Single-Phase Locked- Rotor Currents for Selection of Disconnecting Means and Controllers as Determined from Horsepower and Voltage Rating**

Rated Horsepower	Maximum Locked-Rotor Current in Amperes, Single Phase		
	115 Volts	208 Volts	230 Volts
½	58.8	32.5	29.4
¾	82.8	45.8	41.4
1	96	53	48
1 ½	120	66	60
2	144	80	72
3	204	113	102
5	336	186	168
7 ½	480	265	240
10	600	332	300

Table 430.251(B) **Conversion Table of Polyphase Design B, C, and D Maximum Locked-Rotor Currents for Selection of Disconnecting Means and Controllers as Determined from Horsepower and Voltage Rating and Design Letter**

Rated Horsepower	Maximum Motor Locked-Rotor Current in Amperes, Two- and Three-Phase, Design B, C, and D*					
	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts
	B, C, D	B, C, D	B, C, D	B, C, D	B, C, D	B, C, D
½	40	23	22.1	20	10	8
¾	50	28.8	27.6	25	12.5	10
1	60	34.5	33	30	15	12
1½	80	46	44	40	20	16
2	100	57.5	55	50	25	20
3	—	73.6	71	64	32	25.6
5	—	105.8	102	92	46	36.8
7½	—	146	140	127	63.5	50.8
10	—	186.3	179	162	81	64.8
15	—	267	257	232	116	93
20	—	334	321	290	145	116
25	—	420	404	365	183	146
30	—	500	481	435	218	174
40	—	667	641	580	290	232
50	—	834	802	725	363	290
60	—	1001	962	870	435	348
75	—	1248	1200	1085	543	434
100	—	1668	1603	1450	725	580
125	—	2087	2007	1815	908	726
150	—	2496	2400	2170	1085	868
200	—	3335	3207	2900	1450	1160
250	—	—	—	—	1825	1460
300	—	—	—	—	2200	1760
350	—	—	—	—	2550	2040
400	—	—	—	—	2900	2320
450	—	—	—	—	3250	2600
500	—	—	—	—	3625	2900

*Design A motors are not limited to a maximum starting current or locked rotor current.

These tables for use only with 430.110, 440.12, 440.41 and 455.8(C).

Table 8 **Conductor Properties**

Size (AWG or kcmil)	Area		Conductors							Direct-Current Resistance at 75°C (167°F)					
			Stranding			Overall				Copper				Aluminum	
			Quantity	Diameter		Diameter		Area		Uncoated		Coated			
	mm2	Circular mils		mm	in.	mm	in.	mm2	in.2	ohm/ km	ohm/ kFT	ohm/ km	ohm/ kFT	ohm/ km	ohm/ kFT
18	0.823	1620	1	—	—	1.02	0.040	0.823	0.001	25.5	7.77	26.5	8.08	42.0	12.8
18	0.823	1620	7	0.39	0.015	1.16	0.046	1.06	0.002	26.1	7.95	27.7	8.45	42.8	13.1
16	1.31	2580	1	—	—	1.29	0.051	1.31	0.002	16.0	4.89	16.7	5.08	26.4	8.05
16	1.31	2580	7	0.49	0.019	1.46	0.058	1.68	0.003	16.4	4.99	17.3	5.29	26.9	8.21
14	2.08	4110	1	—	—	1.63	0.064	2.08	0.003	10.1	3.07	10.4	3.19	16.6	5.06
14	2.08	4110	7	0.62	0.024	1.85	0.073	2.68	0.004	10.3	3.14	10.7	3.26	16.9	5.17
12	3.31	6530	1	—	—	2.05	0.081	3.31	0.005	6.34	1.93	6.57	2.01	10.45	3.18
12	3.31	6530	7	0.78	0.030	2.32	0.092	4.25	0.006	6.50	1.98	6.73	2.05	10.69	3.25
10	5.261	10380	1	—	—	2.588	0.102	5.26	0.008	3.984	1.21	4.148	1.26	6.561	2.00
10	5.261	10380	7	0.98	0.038	2.95	0.116	6.76	0.011	4.070	1.24	4.226	1.29	6.679	2.04
8	8.367	16510	1	—	—	3.264	0.128	8.37	0.013	2.506	0.764	2.579	0.786	4.125	1.26
8	8.367	16510	7	1.23	0.049	3.71	0.146	10.76	0.017	2.551	0.778	2.653	0.809	4.204	1.28
6	13.30	26240	7	1.56	0.061	4.67	0.184	17.09	0.027	1.608	0.491	1.671	0.510	2.652	0.808
4	21.15	41740	7	1.96	0.077	5.89	0.232	27.19	0.042	1.010	0.308	1.053	0.321	1.666	0.508
3	26.67	52620	7	2.20	0.087	6.60	0.260	34.28	0.053	0.802	0.245	0.833	0.254	1.320	0.403
2	33.62	66360	7	2.47	0.097	7.42	0.292	43.23	0.067	0.634	0.194	0.661	0.201	1.045	0.319
1	42.41	83690	19	1.69	0.066	8.43	0.332	55.80	0.087	0.505	0.154	0.524	0.160	0.829	0.253
1/0	53.49	105600	19	1.89	0.074	9.45	0.372	70.41	0.109	0.399	0.122	0.415	0.127	0.660	0.201
2/0	67.43	133100	19	2.13	0.084	10.62	0.418	88.74	0.137	0.3170	0.0967	0.329	0.101	0.523	0.159
3/0	85.01	167800	19	2.39	0.094	11.94	0.470	111.9	0.173	0.2512	0.0766	0.2610	0.0797	0.413	0.126
4/0	107.2	211600	19	2.68	0.106	13.41	0.528	141.1	0.219	0.1996	0.0608	0.2050	0.0626	0.328	0.100
250	127	—	37	2.09	0.082	14.61	0.575	168	0.260	0.1687	0.0515	0.1753	0.0535	0.2778	0.0847
300	152	—	37	2.29	0.090	16.00	0.630	201	0.312	0.1409	0.0429	0.1463	0.0446	0.2318	0.0707
350	177	—	37	2.47	0.097	17.30	0.681	235	0.364	0.1205	0.0367	0.1252	0.0382	0.1984	0.0605
400	203	—	37	2.64	0.104	18.49	0.728	268	0.416	0.1053	0.0321	0.1084	0.0331	0.1737	0.0529
500	253	—	37	2.95	0.116	20.65	0.813	336	0.519	0.0845	0.0258	0.0869	0.0265	0.1391	0.0424
600	304	—	61	2.52	0.099	22.68	0.893	404	0.626	0.0704	0.0214	0.0732	0.0223	0.1159	0.0353
700	355	—	61	2.72	0.107	24.49	0.964	471	0.730	0.0603	0.0184	0.0622	0.0189	0.0994	0.0303
750	380	—	61	2.82	0.111	25.35	0.998	505	0.782	0.0563	0.0171	0.0579	0.0176	0.0927	0.0282
800	405	—	61	2.91	0.114	26.16	1.030	538	0.834	0.0528	0.0161	0.0544	0.0166	0.0868	0.0265
900	456	—	61	3.09	0.122	27.79	1.094	606	0.940	0.0470	0.0143	0.0481	0.0147	0.0770	0.0235
1000	507	—	61	3.25	0.128	29.26	1.152	673	1.042	0.0423	0.0129	0.0434	0.0132	0.0695	0.0212
1250	633	—	91	2.98	0.117	32.74	1.289	842	1.305	0.0338	0.0103	0.0347	0.0106	0.0554	0.0169
1500	760	—	91	3.26	0.128	35.86	1.412	1011	1.566	0.02814	0.00858	0.02814	0.00883	0.0464	0.0141
1750	887	—	127	2.98	0.117	38.76	1.526	1180	1.829	0.02410	0.00735	0.02410	0.00756	0.0397	0.0121
2000	1013	—	127	3.19	0.126	41.45	1.632	1349	2.092	0.02109	0.00643	0.02109	0.00662	0.0348	0.0106

Notes:

1. These resistance values are valid only for the parameters as given. Using conductors having coated strands, different stranding type, and, especially, other temperatures changes the resistance.
2. Formula for temperature change: $R2 = R1\ [1 + \alpha\ (T\ 2 - 75)]$ where $\alpha\ cu = 0.00323$, α AL = 0.00330 at 75°C.
3. Conductors with compact and compressed stranding have about 9 percent and 3 percent, respectively, smaller bare conductor diameters than those shown. See Table 5A for actual compact cable dimensions.
4. The IACS conductivities used: bare copper = 100%, aluminum = 61%.
5. Class B stranding is listed as well as solid for some sizes. Its overall diameter and area is that of its circumscribing circle.

Table 9 Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 60 Hz, 75°C (167°F) — Three Single Conductors in Conduit

Size (AWG or kcmil)	Ohms to Neutral per Kilometer Ohms to Neutral per 1000 Feet6														Size (AWG or kcmil)
	XL (Reactance) for All Wires		Alternating-Current Resistance for Uncoated Copper Wires			Alternating-Current Resistance for Aluminum Wires			Effective *Z* at 0.85 *PF* for Uncoated Copper Wires			Effective *Z* at 0.85 *PF* for Aluminum Wires			
	PVC, Aluminum Conduits	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	
14	0.190	0.240	10.2	10.2	10.2	—	—	—	8.9	8.9	8.9	—	—	—	14
0.058	0.073	3.1	3.1	3.1	—	—	—	2.7	2.7	2.7	—	—	—		
12	0.177	0.223	6.6	6.6	6.6	10.5	10.5	10.5	5.6	5.6	5.6	9.2	9.2	9.2	12
0.054	0.068	2.0	2.0	2.0	3.2	3.2	3.2	1.7	1.7	1.7	2.8	2.8	2.8		
10	0.164	0.207	3.9	3.9	3.9	6.6	6.6	6.6	3.6	3.6	3.6	5.9	5.9	5.9	10
0.050	0.063	1.2	1.2	1.2	2.0	2.0	2.0	1.1	1.1	1.1	1.8	1.8	1.8		
8	0.171	0.213	2.56	2.56	2.56	4.3	4.3	4.3	2.26	2.26	2.30	3.6	3.6	3.6	8
0.052	0.065	0.78	0.78	0.78	1.3	1.3	1.3	0.69	0.69	0.70	1.1	1.1	1.1		
6	0.167	0.210	1.61	1.61	1.61	2.66	2.66	2.66	1.44	1.48	1.48	2.33	2.36	2.36	6
0.051	0.064	0.49	0.49	0.49	0.81	0.81	0.81	0.44	0.45	0.45	0.71	0.72	0.72		
4	0.157	0.197	1.02	1.02	1.02	1.67	1.67	1.67	0.95	0.95	0.98	1.51	1.51	1.51	4
0.048	0.060	0.31	0.31	0.31	0.51	0.51	0.51	0.29	0.29	0.30	0.46	0.46	0.46		
3	0.154	0.194	0.82	0.82	0.82	1.31	1.35	1.31	0.75	0.79	0.79	1.21	1.21	1.21	3
0.047	0.059	0.25	0.25	0.25	0.40	0.41	0.40	0.23	0.24	0.24	0.37	0.37	0.37		
2	0.148	0.187	0.62	0.66	0.66	1.05	1.05	1.05	0.62	0.62	0.66	0.98	0.98	0.98	2
0.045	0.057	0.19	0.20	0.20	0.32	0.32	0.32	0.19	0.19	0.20	0.30	0.30	0.30		
1	0.151	0.187	0.49	0.52	0.52	0.82	0.85	0.82	0.52	0.52	0.52	0.79	0.79	0.82	1
0.046	0.057	0.15	0.16	0.16	0.25	0.26	0.25	0.16	0.16	0.16	0.24	0.24	0.25		
1/0	0.144	0.180	0.39	0.43	0.39	0.66	0.69	0.66	0.43	0.43	0.43	0.62	0.66	0.66	1/0
0.044	0.055	0.12	0.13	0.12	0.20	0.21	0.20	0.13	0.13	0.13	0.19	0.20	0.20		
2/0	0.141	0.177	0.33	0.33	0.33	0.52	0.52	0.52	0.36	0.36	0.36	0.52	0.52	0.52	2/0
0.043	0.054	0.10	0.10	0.10	0.16	0.16	0.16	0.11	0.11	0.11	0.16	0.16	0.16		
3/0	0.138	0.171	0.253	0.269	0.259	0.43	0.43	0.43	0.289	0.302	0.308	0.43	0.43	0.46	3/0
0.042	0.052	0.077	0.082	0.079	0.13	0.13	0.13	0.088	0.092	0.094	0.13	0.13	0.14		
4/0	0.135	0.167	0.203	0.220	0.207	0.33	0.36	0.33	0.243	0.256	0.262	0.36	0.36	0.36	4/0
0.041	0.051	0.062	0.067	0.063	0.10	0.11	0.10	0.074	0.078	0.080	0.11	0.11	0.11		
250	0.135	0.171	0.171	0.187	0.177	0.279	0.295	0.282	0.217	0.230	0.240	0.308	0.322	0.33	250
0.041	0.052	0.052	0.057	0.054	0.085	0.090	0.086	0.066	0.070	0.073	0.094	0.098	0.10		
300	0.135	0.167	0.144	0.161	0.148	0.233	0.249	0.236	0.194	0.207	0.213	0.269	0.282	0.289	300
0.041	0.051	0.044	0.049	0.045	0.071	0.076	0.072	0.059	0.063	0.065	0.082	0.086	0.088		
350	0.131	0.164	0.125	0.141	0.128	0.200	0.217	0.207	0.174	0.190	0.197	0.240	0.253	0.262	350
0.040	0.050	0.038	0.043	0.039	0.061	0.066	0.063	0.053	0.058	0.060	0.073	0.077	0.080		
400	0.131	0.161	0.108	0.125	0.115	0.177	0.194	0.180	0.161	0.174	0.184	0.217	0.233	0.240	400
0.040	0.049	0.033	0.038	0.035	0.054	0.059	0.055	0.049	0.053	0.056	0.066	0.071	0.073		
500	0.128	0.157	0.089	0.105	0.095	0.141	0.157	0.148	0.141	0.157	0.164	0.187	0.200	0.210	500
0.039	0.048	0.027	0.032	0.029	0.043	0.048	0.045	0.043	0.048	0.050	0.057	0.061	0.064		
600	0.128	0.157	0.075	0.092	0.082	0.118	0.135	0.125	0.131	0.144	0.154	0.167	0.180	0.190	600
0.039	0.048	0.023	0.028	0.025	0.036	0.041	0.038	0.040	0.044	0.047	0.051	0.055	0.058		
750	0.125	0.157	0.062	0.079	0.069	0.095	0.112	0.102	0.118	0.131	0.141	0.148	0.161	0.171	750
0.038	0.048	0.019	0.024	0.021	0.029	0.034	0.031	0.036	0.040	0.043	0.045	0.049	0.052		
1000	0.121	0.151	0.049	0.062	0.059	0.075	0.089	0.082	0.105	0.118	0.131	0.128	0.138	0.151	1000
0.037	0.046	0.015	0.019	0.018	0.023	0.027	0.025	0.032	0.036	0.040	0.039	0.042	0.046		

Notes:

1. These values are based on the following constants: UL-Type RHH wires with Class B stranding, in cradled configuration. Wire conductivities are 100 percent IACS copper and 61 percent IACS aluminum, and aluminum conduit is 45 percent IACS. Capacitive reactance is ignored, since it is negligible at these voltages. These resistance values are valid only at 75°C (167°F) and for the parameters as given, but are representative for 600-volt wire types operating at 60 Hz.

2. *Effective Z* is defined as $R \cos(\theta) + X \sin(\theta)$, where θ is the power factor angle of the circuit. Multiplying current by effective impedance gives a good approximation for line-to-neutral voltage drop. Effective impedance values shown in this table are valid only at 0.85 power factor. For another circuit power factor (*PF*), effective impedance (*Ze*) can be calculated from *R* and XL values given in this table as follows: $Ze = R \times PF + XL \sin[\arccos(PF)]$.

Table C.4 **Maximum Number of Conductors or Fixture Wires in Intermediate Metal Conduit (IMC) (Based on Table 1, Chapter 9)**

Type	CONDUCTORS										
	Size	Metric Designator (Trade Size)									
	(AWG/ kcmil)	16 (½)	21 (¾)	27 (1)	35 (1¼)	41 (1½)	53 (2)	63 (2½)	78 (3)	91 (3½)	103 (4)
RHH, RHW, RHW-2	14	4	8	13	22	30	49	70	108	144	186
	12	4	6	11	18	25	41	58	89	120	154
	10	3	5	8	15	20	33	47	72	97	124
	8	1	3	4	8	10	17	24	38	50	65
	6	1	1	3	6	8	14	19	30	40	52
	4	1	1	3	5	6	11	15	23	31	41
	3	1	1	2	4	6	9	13	21	28	36
	2	1	1	1	3	5	8	11	18	24	31
	1	0	1	1	2	3	5	7	12	16	20
	1/0	0	1	1	1	3	4	6	10	14	18
	2/0	0	1	1	1	2	4	6	9	12	15
	3/0	0	0	1	1	1	3	5	7	10	13
	4/0	0	0	1	1	1	3	4	6	9	11
	250	0	0	1	1	1	1	3	5	6	8
	300	0	0	0	1	1	1	3	4	6	7
	350	0	0	0	1	1	1	2	4	5	7
	400	0	0	0	1	1	1	2	3	5	6
	500	0	0	0	1	1	1	1	3	4	5
	600	0	0	0	0	1	1	1	2	3	4
	700	0	0	0	0	1	1	1	2	3	4
	750	0	0	0	0	1	1	1	1	3	4
	800	0	0	0	0	0	1	1	1	3	3
	900	0	0	0	0	0	1	1	1	2	3
	1000	0	0	0	0	0	1	1	1	2	3
	1250	0	0	0	0	0	1	1	1	1	2
	1500	0	0	0	0	0	0	1	1	1	1
	1750	0	0	0	0	0	0	1	1	1	1
	2000	0	0	0	0	0	0	1	1	1	1
TW	14	10	17	27	47	64	104	147	228	304	392
	12	7	13	21	36	49	80	113	175	234	301
	10	5	9	15	27	36	59	84	130	174	224
	8	3	5	8	15	20	33	47	72	97	124
RHH*, RHW*, RHW-2*, THHW, THW, THW-2	14	6	11	18	31	42	69	98	151	202	261
	12	5	9	14	25	34	56	79	122	163	209
	10	4	7	11	19	26	43	61	95	127	163
	8	2	4	7	12	16	26	37	57	76	98
	6	1	3	5	9	12	20	28	43	58	75
	4	1	2	4	6	9	15	21	32	43	56
	3	1	1	3	6	8	13	18	28	37	48
	2	1	1	3	5	6	11	15	23	31	41
	1	1	1	1	3	4	7	11	16	22	28
	1/0	1	1	1	3	4	6	9	14	19	24
	2/0	0	1	1	2	3	5	8	12	16	20
	3/0	0	1	1	1	3	4	6	10	13	17
	4/0	0	1	1	1	2	4	5	8	11	14
	250	0	0	1	1	1	3	4	7	9	12
	300	0	0	1	1	1	2	4	6	8	10
	350	0	0	1	1	1	2	3	5	7	9
	400	0	0	0	1	1	1	3	4	6	8
	500	0	0	0	1	1	1	2	4	5	7
	600	0	0	0	1	1	1	1	3	4	5
	700	0	0	0	0	1	1	1	3	4	5

	750	0	0	0	0	1	1	1	2	3	4
	800	0	0	0	0	1	1	1	2	3	4
	900	0	0	0	0	1	1	1	2	3	4
	1000	0	0	0	0	0	1	1	1	3	3
	1250	0	0	0	0	0	1	1	1	1	3
	1500	0	0	0	0	0	1	1	1	1	2
	1750	0	0	0	0	0	0	1	1	1	1
	2000	0	0	0	0	0	0	1	1	1	1
THHN, THWN,	14	14	24	39	68	91	149	211	326	436	562
THWN-2	12	10	17	29	49	67	109	154	238	318	410
	10	6	11	18	31	42	68	97	150	200	258
	8	3	6	10	18	24	39	56	86	115	149
	6	2	4	7	13	17	28	40	62	83	107
	4	1	3	4	8	10	17	25	38	51	66
	3	1	2	4	6	9	15	21	32	43	56
	2	1	1	3	5	7	12	17	27	36	47
	1	1	1	2	4	5	9	13	20	27	35
	1/0	1	1	1	3	4	8	11	17	23	29
	2/0	1	1	1	3	4	6	9	14	19	24
	3/0	0	1	1	2	3	5	7	12	16	20
	4/0	0	1	1	1	2	4	6	9	13	17
	250	0	0	1	1	1	3	5	8	10	13
	300	0	0	1	1	1	3	4	7	9	12
	350	0	0	1	1	1	2	4	6	8	10
	400	0	0	1	1	1	2	3	5	7	9
	500	0	0	0	1	1	1	3	4	6	7
	600	0	0	0	1	1	1	2	3	5	6
	700	0	0	0	1	1	1	1	3	4	5
	750	0	0	0	1	1	1	1	3	4	5
	800	0	0	0	0	1	1	1	3	4	5
	900	0	0	0	0	1	1	1	2	3	4
	1000	0	0	0	0	1	1	1	2	3	4
FEP, FEPB,	14	13	23	38	66	89	145	205	317	423	545
PFA, PFAH,	12	10	17	28	48	65	106	150	231	309	398
TFE	10	7	12	20	34	46	76	107	166	221	285
	8	4	7	11	19	26	43	61	95	127	163
	6	3	5	8	14	19	31	44	67	90	116
	4	1	3	5	10	13	21	30	47	63	81
	3	1	3	4	8	11	18	25	39	52	68
	2	1	2	4	6	9	15	21	32	43	56
PFA, PFAH,	1	1	1	2	4	6	10	14	22	30	39
TFE	1/0	1	1	1	4	5	8	12	19	25	32
	2/0	1	1	1	3	4	7	10	15	21	27
	3/0	0	1	1	2	3	6	8	13	17	22
	4/0	0	1	1	1	3	5	7	10	14	18
Z	14	16	28	46	79	107	175	247	381	510	657
	12	11	20	32	56	76	124	175	271	362	466
	10	7	12	20	34	46	76	107	166	221	285
	8	4	7	12	21	29	48	68	105	140	180
	6	3	5	9	15	20	33	47	73	98	127
	4	1	3	6	10	14	23	33	50	67	87
	3	1	2	4	7	10	17	24	37	49	63
	2	1	1	3	6	8	14	20	30	41	53
	1	1	1	3	5	7	11	16	25	33	43
XHH, XHHW,	14	10	17	27	47	64	104	147	228	304	392
XHHW-2, ZW	12	7	13	21	36	49	80	113	175	234	301
	10	5	9	15	27	36	59	84	130	174	224
	8	3	5	8	15	20	33	47	72	97	124
	6	1	4	6	11	15	24	35	53	71	92
	4	1	3	4	8	11	18	25	39	52	67

	3	1	2	4	7	9	15	21	33	44	56
	2	1	1	3	5	7	12	18	27	37	47
	1	1	1	2	4	5	9	13	20	27	35
	1/0	1	1	1	3	5	8	11	17	23	30
	2/0	1	1	1	3	4	6	9	14	19	25
	3/0	0	1	1	2	3	5	7	12	16	20
	4/0	0	1	1	1	2	4	6	10	13	17
	250	0	0	1	1	1	3	5	8	11	14
	300	0	0	1	1	1	3	4	7	9	12
	350	0	0	1	1	1	3	4	6	8	10
	400	0	0	1	1	1	2	3	5	7	9
	500	0	0	0	1	1	1	3	4	6	8
	600	0	0	0	1	1	1	2	3	5	6
	700	0	0	0	1	1	1	1	3	4	5
	750	0	0	0	1	1	1	1	3	4	5
	800	0	0	0	0	1	1	1	3	4	5
	900	0	0	0	0	1	1	1	2	3	4
	1000	0	0	0	0	1	1	1	2	3	4
	1250	0	0	0	0	0	1	1	1	2	3
	1500	0	0	0	0	0	1	1	1	1	2
	1750	0	0	0	0	0	1	1	1	1	2
	2000	0	0	0	0	0	0	1	1	1	1

NEMA Controller Size for Motors, Transformers, & Capacitors

	Load Voltage	Contin-uous Current	Service Limit Current	Motor Maximum		Motor Maximum		Transformer Primary Switching		Transformer Primary Switching		Capacitor Switching	Circuit Closing Maximum
				Non-plugging and Non-jogging Duty		Plugging and Jogging Duty		Inrush Current < = 20 times Continuous Amp		Inrush Current = 20 to 40 times Continuous Amp			Inrush Current Peak Including Offset
NEMA	V	Amp	Amp	HP	HP	HP	HP	kVA	kVA	kVA	kVA	kVAR	Amp
Size				1φ	3 φ	1 φ	3 φ	1 φ	3 φ	1 φ	3 φ	3 φ	3 φ
00	115	9	11	1/3	—	1/4	—	—	—	—	—	—	87
	200			—	1-1/2	—	1	—	—	—	—	—	
	230			1	1-1/2	1/2	1	—	—	—	—	—	
	380			—	1-1/2	—	1	—	—	—	—	—	
	460			—	2	—	1-1/2	—	—	—	—	—	
	575			—	2	—	1-1/2	—	—	—	—	—	
0	115	18	21	1	—	1/2	—	0.6	—	0.3	—	—	140
	200			—	3	—	1-1/2	—	1.8	—	0.9	—	
	230			2	3	1	1-1/2	1.2	2.1	0.6	1	—	
	380			—	5	—	1-1/2	—	—	—	—	—	
	460			—	5	—	2	2.4	4.2	1.2	2.1	—	
	575			—	5	—	2	3	5.2	1.5	2.6	—	
1	115	27	32	2	—	1	—	1.2	—	0.6	—	—	288
	200			—	7-1/2	—	3	—	3.6	—	1.8	—	
	230			3	7-1/2	2	3	2.4	4.3	1.2	2.1	6	
	380			—	10	—	5	—	—	—	—	—	
	460			—	10	—	5	4.9	8.5	2.5	4.3	13.5	
	575			—	10	—	5	6.2	11	3.1	5.3	17	
1P	115	36	42	3	—	1-1/2	—	—	—	—	—	—	—
	230			5	—	3	—	—	—	—	—	—	—
2	115	45	52	3	—	2	—	2.1	—	1	—	—	483
	200			—	10	—	7-1/2	—	6.3	—	3.1	—	
	230			7-1/2	15	5	10	4.1	7.2	2.1	3.6	12	
	380			—	25	—	15	—	—	—	—	—	
	460			—	25	—	15	8.3	14	4.2	7.2	25	
	575			—	25	—	15	10	18	5.2	8.9	31	
3	115	90	104	7-1/2	—	7-1/2	—	4.1	—	2	—	—	947
	200			—	25	—	15	—	12	—	6.1	—	
	230			15	30	15	20	8.1	14	4.1	7.0	27	
	380			—	50	—	30	—	—	—	—	—	
	460			—	50	—	30	16	28	8.1	14	53	
	575			—	50	—	30	20	35	10	18	67	
4	115	135	156	—	—	—	—	6.8	—	3.4	—	—	1581
	200			—	40	—	25	—	20	—	10	—	
	230			—	50	—	30	14	23	6.8	12	40	
	380			—	75	—	50	—	—	—	—	—	
	460			—	100	—	60	27	47	14	23	80	
	575			—	100	—	60	34	59	17	29	100	
5	115	270	311	—	—	—	—	14	—	6.8	—	—	3163
	200			—	75	—	60	—	41	—	20	—	
	230			—	100	—	75	27	47	14	24	80	
	380			—	150	—	125	—	—	—	—	—	
	460			—	200	—	150	54	94	27	47	160	
	575			—	200	—	150	68	117	34	59	200	
6	115	540	621	—	—	—	—	27	—	14	—	—	6326
	200			—	150	—	125	—	81	—	41	—	
	230			—	200	—	150	54	94	27	47	160	
	380			—	300	—	250	—	—	—	—	—	
	460			—	400	—	300	108	188	54	94	320	
	575			—	400	—	300	135	234	68	117	400	
7	230	810	932	—	300	—	—	—	—	—	—	240	9470
	460			—	600	—	—	—	—	—	—	480	
	575			—	600	—	—	—	—	—	—	600	
8	230	1215	1400	—	450	—	—	—	—	—	—	360	14205
	460			—	900	—	—	—	—	—	—	720	
	575			—	900	—	—	—	—	—	—	900	
9	230	2250	2590	—	800	—	—	—	—	—	—	665	25380
	460			—	1600	—	—	—	—	—	—	1325	
	575			—	1600	—	—	—	—	—	—	1670	

Service-Limit Current Ratings - The service-limit current ratings shown represent the maximum rms current, in amperes, which the controller shall be permitted to carry for protracted periods in normal service. At service-limit current ratings, temperature rises shall be permitted to exceed those obtained by testing the controller at its continuous current rating. The current rating of overload relays or the trip current of other motor protective devices used shall not exceed the service-limit current rating of the controller.

Plugging or Jogging Service - The listed horsepower ratings are recommended for those applications requiring repeated interruption of stalled motor current encountered in rapid motor reversal in excess of five openings or closings per minute and shall not be more than ten in a ten minute period.

Capacitor terminals - If maximum available current is greater than 3,000 amperes, consult NEMA ICS-2 Standard.

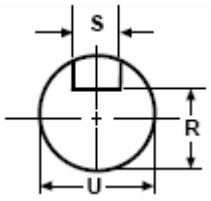
NEMA Table 11 **Typical Characteristics and Applications of Fixed Frequency Small and Medium AC Squirrel-Cage Induction Motors**

Design Letter	Locked Rotor Torque	Pull-up Torque	Break-down Torque	Locked Rotor Current	Slip	Typical Applications	Relative Efficiency
Polyphase Characteristics	**Percent Rated Load Torque***	**Percent Rated Load Torque**	**Percent Rated Load Torque**	**Percent Rated Load Current**	**Percent Sync Speed**		
Design A High locked rotor torque High locked rotor current	70-275	65-190	175-300	Not defined	0.5-5%	Fans, blowers, centrifugal pumps and compressors, motor-generator sets, etc., where starting torque requirements are relatively low.	Medium or high
Design B Normal locked rotor torque Normal locked rotor current	70-275	65-190	175-300	600-700	0.5-5%	Fans, blowers, centrifugal pumps and compressors, motor-generator sets, etc., where starting torque requirements are relatively low.	Medium or high
Design C High locked rotor torque Normal locked rotor current	200-285	140-195	190-225	600-700	1-5%	Conveyors, crushers, stirring motors, agitators, reciprocating pumps and compressors, etc., where starting under load is required	Medium
Design D High locked rotor torque High slip	275	NA	275	600-700	5-8%	High peak loads with or without flywheels such as punch presses, shears, elevators, extractors, winches, hoists, oil-well pumping and wire-drawing motors	Low
Design N Small motor	-	NA	-	-	-	Centrifugal loads where starting torque requirements are relatively low.	Low
Design 0 Small motor	-	NA	-	-	NA		
Design L Medium motor	-	100%	-	-	NA	Fans, blowers, centrifugal pumps and compressors, motor-generator sets, etc., where starting torque requirements are relatively low.	Medium or low
Design M Medium motor	-	100%	-	-	NA	Fans, blowers, centrifugal pumps and compressors, motor-generator sets, etc., where starting torque requirements are relatively low.	Medium or low

*Higher values are for motors having lower horsepower ratings.

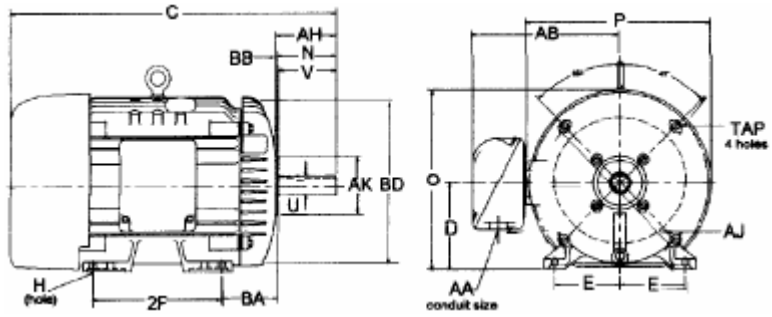
NEMA MOTOR DIMENSIONS

Shaft – Key Dimensions



NEMA Shaft (U)	Key (R)	Dimen (S)
3/8	21/64	flat
1/2	29/64	flat
5/8	33/64	3/16
7/8	49/64	3/16
1-1/8	63/64	1/4
1-3/8	1-13/64	5/16
1-5/8	1-13/32	3/8
1-7/8	1-19/32	1/2
2-1/8	1-27/32	1/2
2-3/8	2-1/64	5/8
2-1/2	2-3/16	5/8
2-7/8	2-29/64	3/4
3-3/8	2-7/8	7/8
3-7/8	3-5/16	1

Frame Dimensions



Frame	D	E	2F	H	N*	O*	P*	U	V	AA	AB*	AH	AJ	AK	BA	BB	BD*	TAP
42	2-5/8	1-3/4	1-11/16	9/32 slot	1-1/2	5	4-11/16	3/8	1-1/8	3/8	4-1/32	1-5/16	3-3/4	3	2-1/16	1/8	4-5/8	1/4-20
48	3	2-1/8	2-3/4	11/32 slot	1-7/8	5-7/8	5-11/16	1/2	1-1/2	1/2	4-3/8	1-11/16	3-3/4	3	2-1/2	1/8	5-5/8	1/4-20
56	3-1/2	2-7/16	3	11/32 slot	2-7/16	6-7/8	6-5/8	5/8	1-7/8	1/2	5	2-1/16	5-7/8	4-1/2	2-3/4	1/8	6-1/2	3/8-16
56H			5		2-1/8													
143T	3-1/2	2-3/4	4	11/32	2-1/2	6-7/8	6-5/8	7/8	2-1/4	3/4	5-1/4	2-1/8	5-7/8	4-1/2	2-1/4	1/8	6-1/2	3/8-16
145T			5															
182			4-1/2		2-11/16			7/8	2-1/4			2-1/8	5-7/8	4-1/2		1/8	6-1/2	3/8-16
184	4-1/2	3-3/4	5-1/2	13/32	2-11/16	8-11/16	7-7/8	7/8	2-1/4	3/4	5-7/8	2-1/8	5-7/8	4-1/2	2-3/4	1/8	6-1/2	3/8-16
182T			4-1/2		3-9/16			1-1/8	2-3/4			2-5/8	7-1/4	8-1/2		1/4	9	1/2-13
184T			5-1/2		3-9/16			1-1/8	2-3/4			2-5/8	7-1/4	8-1/2		1/4	9	1/2-13
213			5-1/2		3-1/2			1-1/8	3			2-3/4						
215	5-1/4	4-1/4	7	13/32	3-1/2	10-1/4	9-9/16	1-1/8	3	3/4	7-3/8	2-3/4	7-1/4	8-1/2	3-1/2	1/4	9	1/2-13
213T			5-1/2		3-7/8			1-3/8	3-3/8			3-1/8						
215T			7		3-7/8			1-3/8	3-3/8			3-1/8						
254U			8-1/4		4-1/16			1-3/8	3-3/4			3-1/2						
256U	6-1/4	5	10	17/32	4-1/16	12-7/8	12-15/16	1-3/8	3-3/4	1	9-5/8	3-1/2	7-1/4	8-1/2	4-1/4	1/4	10	1/2-13
254T			8-1/4		4-5/16			1-5/8	4			3-3/4						
256T			10		4-5/16			1-5/8	4			3-3/4						
284U			9-1/2		5-1/8			1-5/8	4-7/8			4-5/8						
286U			11		5-1/8			1-5/8	4-7/8			4-5/8						
284T	7	5-1/2	9-1/2	17/32	4-7/8	14-5/8	14-5/8	1-7/8	4-5/8	1-1/2	13-1/8	4-3/8	9	10-1/2	4-3/4	1/4	11-1/4	1/2-13
286T			11		4-7/8			1-7/8	4-5/8			4-3/8						
284TS			9-1/2		3-3/8			1-5/8	3-1/4			3						
286TS			11		3-3/8			1-5/8	3-1/4			3						
324U			10-1/2		5-7/8			1-7/8	5-5/8			5-3/8						
326U			12		5-7/8			1-7/8	5-5/8			5-3/8						
324T	8	6-1/4	10-1/2	21/32	5-1/2			2-1/8	5-1/4	2	14-1/8	5	11	12-1/2	5-1/4	1/4	13-3/8	5/8-11
326T			12		5-1/2	16-1/2	16-1/2	2-1/8	5-1/4			5						
324TS			10-1/2		3-15/16			1-7/8	3-3/4			3-1/2						
326TS			12		3-15/16			1-7/8	3-3/4			3-1/2						
364U			11-1/4		6-3/4			2-1/8	6-3/8			6-1/8						
365U			12-1/4		6-3/4			2-1/8	6-3/8			6-1/8						
364T	9	7	11-1/4	21/32	6-1/4	18-1/2	18-1/4	2-3/8	5-7/8	2-1/2	15-1/16	5-5/8	11	12-1/2	5-7/8	1/4	13-3/8	5/8-11
365T			12-1/4		6-1/4			2-3/8	5-7/8			5-5/8						
364TS			11-1/4		4			1-7/8	3-3/4			3-1/2						
365TS			12-1/4		4			1-7/8	3-3/4			3-1/2						
404U			12-1/4		7-3/16			2-3/8	7-1/8			6-7/8						
405U			13-3/4		7-3/16			2-3/8	7-1/8			6-7/8						
404T	10	8	12-1/4	13/16	7-5/16	20-5/16	20-1/8	2-7/8	7-1/4	3	18	7	11	12-1/2	6-5/8	1/4	13-7/8	5/8-11
405T			13-3/4		7-5/16			2-7/8	7-1/4			7						
404TS			12-1/4		4-1/2			2-1/8	4-1/4			4						
405TS			13-3/4		4-1/2			2-1/8	4-1/4			4						
444U			14-1/2		8-5/8	22-7/8	22-3/8	2-7/8	8-5/8		19-9/16	8-3/8						
445U			16-1/2		8-5/8	22-7/8	22-3/8	2-7/8	8-5/8		19-9/16	8-3/8						
444T			14-1/2		8-1/2	22-7/8	22-3/8	3-3/8	8-1/2		19-9/16	8-1/4						
445T	11	9	16-1/2	13/16	8-1/2	22-7/8	22-3/8	3-3/8	8-1/2		19-9/16	8-1/4						
447T			20		8-15/16	22-15/16	22-3/4	3-3/8	8-1/2	3	21-11/16	8-1/4	14	16	7-1/2	1/4	16-3/4	5/8-11
449T			25		8-15/16	22-15/16	22-3/4	3-3/8	8-1/2		21-11/16	8-1/4						
444TS			14-1/2		5-3/16	22-7/8	22-3/8	2-3/8	4-3/4		19-9/16	4-1/2						
445TS			16-1/2		5-3/16	22-7/8	22-3/8	2-3/8	4-3/4		19-9/16	4-1/2						
447TS			20		4-15/16	22-15/16	22-3/4	2-3/8	4-3/4	4NPT	21-11/16	4-1/2						
449TS			25		4-15/16	22-15/16	22-3/4	2-3/8	4-3/4	4NPT	21-11/16	4-1/2						

NEMA MOTOR DIMENSIONS – 2

Frame Size Information

Suffix letters after the NEMA frame size indicates that the frame differs in some way from the standard frame. Below is a list of suffixes that may be found after the frame size and their definition.

A	DC Motor or Generator
C	"C" flange mounting on drive end **
D	"D" flange mounting on drive end **
E	Shaft dimensions for elevator motors in frames larger than the 326U frame
H	Frame with an "F" dimension larger than a frame without (small framed motors)
J	Jet pump motors
JM	"C"-face mounted close coupling pump with mechanical seal
JP	"C"-face mounted close coupling pump -packed pump
K	Sump pump motor
LP & LPH	"P" flange mounting vertical solid shaft pump
P & PH	"P" flange mounting vertical hollow shaft pump
S	Standard short shaft
T	Included as part of a frame number-standard dimension
U	Included as part of a frame number-standard dimension
V	Vertical mounting
Y	Special mounting dimensions -manufactured specified
Z	Special shaft dimensions -manufactured specified

** If the face mounting is on the end opposite the drive, the suffix will be as follows: "FC" or "FD"

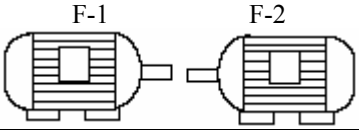
Notes From Front:

-When a "C" flange has been added to a NEMA motor the "BA" dimensions are:

Frame:	"BA":
143-5TC	2-3/4
182-4TC	3-1/2
213-5TC	4-1/4
254-6TC	4-3 4

-Dimensions: C, N, O, P, & AB are specific to each manufacturer. Please call for exact dimensions.

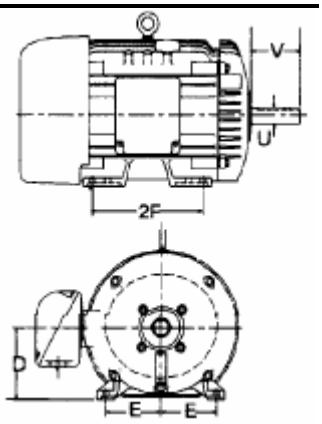
Assembly Position F-1 VS. F-2



Pre-NEMA Dimensions

FRAME	U	V	D	2F	E
203	3/4	2	5	5-1/2	4
204	3/4	2	5	6-1/2	4
224	1	2-3/4	5-1/2	6-3/4	4-1/2
225	1	2-3/4	5-1/2	7-1/2	4-1/2
254	1-1/8	3-1/8	6-1/4	8-1/14	5
284	1-1/4	3-3/4	7	9-1/2	5-1/2
324	1-5/8	4-5/8	8	10-1/2	6-1/4
324S	1-5/8	3	8	10-1/2	6-1/4
326	1-5/8	4-5/8	8	12	6-1/4
326S	1-5/8	3	8	12	6-1/4
364	1-7/8	5-3/8	9	11-1/4	7
364S	1-7/8	3-1/2	9	11-1/4	7
356	1-7/8	5-3/8	9	12-1/4	7
365S	1-5/8	3-1/2	9	12-1/4	7

FRAME	U	V	D	2F	E
404	2-1/8	6-1/8	10	12-1/4	8
404S	1-7/8	3-1/2	10	12-1/4	8
405	2-1/8	6-1/8	10	13-3/4	8
405S	1-7/8	3-/2	10	13-3/4	8
444	2-3/8	6-7/8	11	14-1/2	9
444S	2-1/8	4	11	14-1/2	9
445	2-3/8	6-7/8	11	16-1/2	9
445S	2-1/8	4	11	16-1/2	9
504	2-5/8	7-5/8	12-1/2	16	8
504S	2-1/8	4	12-1/2	16	8
505	2-7/8	8-3/8	12-1/2	18	9
505S	2-1/8	4	12-1/2	18	9
584	2-7/8	11-5/8	14-1/2	18	9
584S	2-3/8	4-3/4	14-1/2	18	9



Standard NEMA Frames vs Horsepower

HP	900 RPM			1200 RPM			1800 RPM			3600 RPM		
	T-Frame 1964-Present	U-Frame 1952-Present	Original NEMA	T-Frame 1964-Present	U-Frame 1952-Present	Original NEMA	T-Frame 1964-Present	U-Frame 1952-Present	Original NEMA	T-Frame 1964-Present	U-Frame 1952-Present	Original NEMA
1	182T	213	225	145T	184	204	143T	182	203	.	.	.
1.5	184T	213	254	182T	184	224	145T	184	204	143T	182	203
2	213T	215	254	184T	213	225	145T	184	224	145T	184	204
3	215T	254U	284	213T	215	254	182T	213	225	145T/182T	184	224
5	254T	256U	324	215T	254U	284	184T	215	254	182T/184T	213	225
7.5	256T	284U	326	254T	256U	324	213T	254U	284	184T/213T	215	254
10	284T	286U	364	256T	284U	326	215T	256U	324	213T/215T	254U	284
15	286T	326U	365	284T	324U	364	254T	284U	326	215T/254T	256U	324
20	324T	364U	404	286T	326U	365	256T	286U	364	254T/256T	284U/286U	326
25	326T	365U	405	324T	364U	404	284T	324U	364/365	256T/284TS	286U/324U	364S/365S
30	364T	404U	444	324T	365U	405	286T	326U	365/404	284TS/286TS	324S/326S	364S/404S
40	365T	405U	445	364T	404U	444	324T	364U	404/405	286TS/324TS	326S/364US	365S/405S
50	404T	444U	504	365T	405U	445	326T	365US	405S/444	324TS/326TS	364US	404S/444S
60	405T	445U	505	404T	444U	504	364TS	404US/405US	444S/445S	326TS/364TS	365US/405US	405S/445S
75	444T	.	.	405T	445U	505	365TS	405US/444US	445S/504S	364TS/365TS	404US/444US	444S/504S
100	445T	.	.	444T	.	.	404TS/405TS	444US/445US	504S/505S	365TS/405TS	405US/445US	445S/505S
125	.	.	.	445T	.	.	405TS/444TS	445US	505S	404TS/444TS	444US	504S
150	.	.	.	. .	.	.	444TS/445TS	.	.	405TS/445TS	445US	505S
200	.	.	.		.	.	455TS	.	.	444TS	.	.
250	.	.	.	.	.	.	.	.	.	445TS	.	.

These charts are provided for reference use only. We are not responsible for any printing errors.

NEMA Motor Enclosure Type

Type	Abbreviation	Description	Designed for use in
Open Drip Proof	ODG	Open Drip-Proof, Guarded	non-hazardous, relatively clean areas, most common type,
	ODG-FV	Open Drip-Proof, Force Ventilated	
	ODG-SV	Open Drip-Proof, Separately Ventilated	
	ODP	Open Drip-Proof	
Totally Enclosed	TEAO	Totally-Enclosed, Air-Over	extremely wet, dirty, or dusty areas
	TEBC	Totally-Enclosed, Blower-Cooled	
	TECACA	Totally-Enclosed, Closed Circuit,, Air to Air	
	TEDC-A/A	Totally-Enclosed, Dual Cooled, Air to Air	
	TEDC-A/W	Totally-Enclosed, Dual Cooled, Air to Water	
	TEFC	Totally-Enclosed, Fan-Cooled	
	TENV	Totally-Enclosed Non-Ventilated	
	TETC	Totally-Enclosed, Tube Cooled	
	TEWAC	Totally-Enclosed, Water/Air Cooled	
	TEXP	Totally-Enclosed, Explosion-Proof	
Weather Protected	WPI	Weather Protected, Type I	adverse outdoor conditions
	WPII	Weather Protected Type II	
Special	XE	Premium Efficient	improved efficiency
	XL	Extra Life	
	XP	Explosion-Proof	withstanding an explosion of a specified dust, gas, or vapor
	XT	Extra Tough	
		Dust ignition proof	preventing the ignition of a dust, gas, or vapor surrounding the motor
IEC	IP-22	Open Drip-Proof	representative IEC designations
	IP-44	Totally-Enclosed	
	IP-54	Splash Proof	
	IP-55	Washdown	

Electrical Power System Design Example

Pump:	20 Hp, 300 RPM, 18” sheave	Pump:
Motor:	3Φ, 460 V	Motor:
Power:	3Φ, 7200 LN	Power:
Environment:	ambient 98F, outdoor	Environment:

#	Measure Parameter	Standard Table or Reference	Example Factor	Example Result	Problem Factor	Problem Result
1	Motor horsepower	NEC 430.250	-	20		
2	Full load Amps - FLA	NEC 430.250	-	27		
3	Lock letter code & kVA/hp	NEC 430.7(B)	F 5.59	112		
4	Lock rotor amp calculate	kVA*1000/1.732 V	112,000/1.732*460	141		
5	Lock rotor amp for disconnect	NEC 430.251(B)	-	145		
6	Wire rating:1.25*largest+other	NEC 430.24	1.25*27 + 0	34		
7	Insulation type	NEC 310-16	-	THHN		
8	Insulation temperature	NEC 310-16	-	90C		
9	AWG / kcmil	NEC 310-16	-	10 AWG		
10	Temperature correction amp	NEC 310-16	0.91	36		
11	Max breaker rating & type	NEC 430.52	800 instant	216		
12	Actual breaker size	NEC 240.6(A)	-	200		
13	Controller enclosure	NEC 430.91	-	3R		
14	Controller size	NEMA Controller	-	2		
15	Controller max closing amp	NEMA Controller	-	483		
16	Overload setting % - Amp	-	105	28.4		
17	Motor enclosure	NEMA Enclosure		TEFC		
18	Motor NEMA design	NEMA 11	-	B		
19	Motor sync speed	120 * freq / poles	120*60/4	1800		
20	Motor slip - shaft speed	NEMA 11	2%	1764		
21	Motor frame	NEMA Dimension 2	-	256T		
22	Shaft diameter	NEMA Dimensions	U	1-5/8		
23	Sheave diameter	P(n*dia) = M(n*dia)	300*18/1800	3”		
24	# wires	-	3Φ + N	4		
25	Conduit type & size	NEC C4 et al	1/2	3/4		
26	Total kVA	1.732 V * I / 1000	1.732*480*27/1000	22.5		
26	Transformer kVA size	NEMA	-	3 – 7.5		
28	Secondary volt & Y-Δ	-		277 / 480 Y		
29	Primary volt & Y-Δ	-		12470 Δ		
30	Transformers taps			two 2-1/2 ±		
31	Transformer impedance PU					