■ **Lubrication.** Too much lubricant is a major cause of premature motor failure. Excess grease is eventually forced out of the bearing housings and begins dripping on the motor windings, resulting in early winding failure. Overlubrication also can reduce bearing life and motor efficiency.

To lubricate standard-duty motors, follow the original manufacturer's specifications. Begin by cleaning the grease fitting and removing the drain plug. After adding the new grease, run the motor for about an hour before reinstalling the drain plug. This purges excess grease without damaging the windings. If the motor manufacturer's lubrication specifications are not available, follow these recommendations.

Table 1. Lubrication Guide

RPM	Frame Range	Type Of Service	
		8 Hours/Day	24 Hours/Day
3600	143T-256T	*	*
	284TS-286TS	6 months	2 months
	324TS-587US	4 months	2 months
1800	143T-256T	*	*
	284T-326T	4 years	18 months
	364T-365T	1 year	4 months
	404T-449T	9 months	3 months
	505U-587U	6 months	2 months
1200 and below	143T-256T	*	*
	284T-326T	4 years	18 months
	364T-449T	1 year	4 months
	505U-587U	9 months	3 months

* Bearings in these motors often cannot be relubricated. They should be replaced at least every 5 years for 8 hour/day service, or every 2 years for 24 hour/day service.

■ **Cleaning.** It is extremely important to keep air passages clean so that the motor can dissipate the heat it develops. The cooling fins of totally enclosed, fan-cooled motors must also be kept free of dirt and debris, because they are the only means of dissipating heat from these machines. To assure proper cooling, make certain nothing prevents sufficient amounts of fresh air from reaching the motors.

■ **Insulation Resistance Testing.** One of the most useful tests for determining when to remove a motor from service for overhaul and/or rewinding is the insulation resistance test. To be effective, this test must be conducted at regular intervals, typically annually. The results must also be recorded for comparison with future readings. This is known as "trending." If the results show a downward trend, the test should be performed more frequently.

To correct insulation resistance readings to the reference temperature, use the following formula:

$\mathbf{R_c = R_t \times K_t}$

Where:

R_c = insulation resistance (in megohms) corrected to 40° C

R_t = measured insulation resistance (in megohms) at temperature t (° C)

K_t = insulation resistance temperature coefficient at temperature t (° C)

Example: Winding temperature t = 68° F = 20° C

Measured resistance R_t = 800 megohms

Referring to Figure 1, find the insulation resistance temperature coefficient:

K_t = 0.25

Multiply 800 megohms times 0.25 to find the corrected resistance:

$R_c = R_t \times K_t$

$= 800 \times 0.25$

$= 200$ megohms

Plot the corrected insulation resistance readings for each test on a chart for reference and trending. The corrected reading of 200 megohms from the above example is shown at "0 months" in Figure 2.

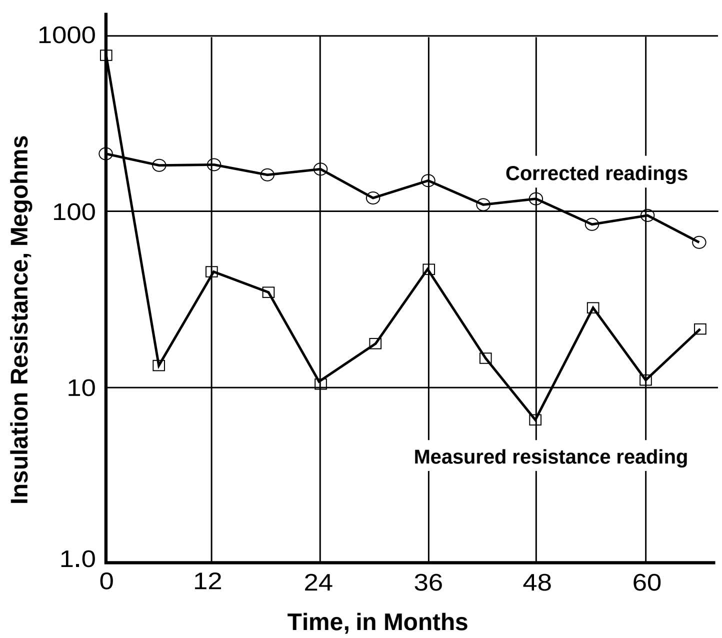


Figure 2. Corrected Insulation Resistance Readings

Application Considerations

■ **Motor Selection.** To extend motor life, be sure to use the right motor for the application (see Figure 4 and Table 2). For instance, for an application that requires starting a high-torque load, a standard, general purpose NEMA Design B motor might be inadequate. A Design C motor, which has more starting torque than either a Design A or Design B motor and yet draws about the same starting current, might be required. If a Design A or Design B motor were used on a high-torque application, the overload protectors might trip before the motor could accelerate the load to operating speed. Even if overload protectors permit the motor to reach running speed, motor life would be shortened due to the additional heat generated during the prolonged starting period. *Be careful not to mistake the insulation class letter or kVA code letter for the design letter.*

Energy efficient motors can trip some circuit breakers because they have higher inrush currents than standard motors.

Other features of the motor, besides torque, must be considered to match the driven load. These include rotating speed (rpm), supply power requirements, duty cycle, and the method of starting. The physical environment can introduce other factors, such as corrosives, moisture, temperature extremes, and position (e.g., vertical mounting).

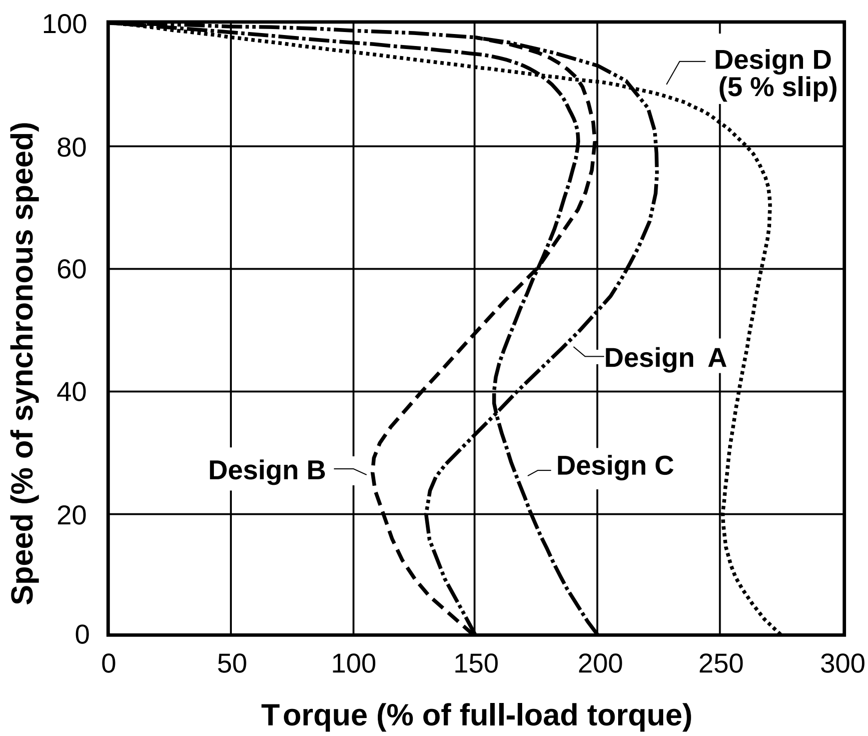


Figure 4. General Speed-Torque Characteristics

Table 2. NEMA Torque Designs For Three-Phase Motors

NEMA Design	Locked Rotor Torque	Breakdown Torque	Locked Rotor Current	Percent Slip	Relative Efficiency
B	70 - 275%*	175 - 300%*	600 - 700%	0.5-5%	Medium or High
	Applications: Fans, blowers, centrifugal pumps and compressors, motor-generator sets, etc., where starting torque requirements are relatively low.				
C	200 - 250%*	190 - 225%*	600 - 700%	1-5%	Medium
	Applications: Conveyors, crushers, stirring machines, agitators, reciprocating pumps and compressors, etc., where starting under load is required.				
D	275%	275%	600 - 700%	5 - 8% 8 - 13% 15 - 25%	Medium
	Applications: High peak loads with or without flywheels, such as punch presses, shears,elevators, extractors winches, hoists, oil-well pumping, and wire-drawing machines.				

Based on NEMA Standards MG 10, Table 2-1. NEMA Design A is a variation of Design B having higher locked-rotor current.

*Higher values are for motors having lower horsepower ratings.

■ **Continuous Duty Motors.** Continuous duty motors should not be used in applications that require frequent starting or reversing unless special provisions are made. These motors must be allowed to run long enough after each start to dissipate the heat that builds up as about six to eight times rated full-load current passes through the windings during the starting period.

■ **Allowable Number Of Motor Starts.** The inertia of the load, motor horsepower and speed (poles) determine the allowable number of times per hour a motor may be started (NEMA MG 1-1998, 12.55). Table 3 (Page 11) indicates the number of starts per hour and the minimum rest or "off time" between starts for a number of common motor ratings. It is based on starting at rated voltage and frequency, with a load Wk^2 and torque within limits shown in Table 4 (Page 12).

Table 3. Allowable Starts And Starting Intervals (Design A and B Motors)

HP	2 Pole			4 Pole			6 Pole		
	A	B	C	A	B	C	A	B	C
1	15	1.2	75	30	5.8	38	34	15	33
1.5	12.9	1.8	76	25.7	8.6	38	29.1	23	34
2	11.5	2.4	77	23	11	39	26.1	30	35
3	9.9	3.5	80	19.8	17	40	22.4	44	36
5	8.1	5.7	83	16.3	27	42	18.4	71	37
7.5	7.0	8.3	88	13.9	39	44	15.8	104	39
10	6.2	11	92	12.5	51	46	14.2	137	41
15	5.4	16	100	10.7	75	50	12.1	200	44
20	4.8	21	110	9.6	99	55	10.9	262	48
25	4.4	26	115	8.8	122	58	10.0	324	51
30	4.1	31	120	8.2	144	60	9.3	384	53
40	3.7	40	130	7.4	189	65	8.4	503	57
50	3.4	49	145	6.8	232	72	7.7	620	64
60	3.2	58	170	6.3	275	85	7.2	735	75
75	2.9	71	180	5.8	338	90	6.6	904	79
100	2.6	92	220	5.2	441	110	5.9	1181	97
125	2.4	113	275	4.8	542	140	5.4	1452	120
150	2.2	133	320	4.5	640	160	5.1	1719	140
200	2.0	172	600	4.0	831	300	4.5	2238	265
250	1.8	210	1000	3.7	1017	500	4.2	2744	440

Where: A = Maximum number of starts per hour.
B = Maximum product of starts per hour times load Wk^2.
C = Minimum rest or off time in seconds between starts.
Allowable starts per hour is the lesser of (1) A or (2) B divided by the load Wk^2—i. e.,

Starts per hour $\leq A$ or $\leq B/Wk^2$, whichever is less.

Note: Table 3 is based on following conditions:

1. Applied voltage and frequency in accordance with MG 1-1998, 12.45.
2. During the accelerating period, the connected load torque is equal to or less than a torque which varies as the square of the speed and is equal to 100 percent of rated torque at rated speed.
3. External load Wk^2 equal to or less than the values listed in Column B.

For other conditions, consult the manufacturer.

Reference: NEMA Standards MG 10, Table 2-3.

Example: 25 horsepower motor, 4 poles, with an actual load Wk^2 of 50.

1. From the Table 3, A = 8.8 and B = 122.
2. Calculate $B/Wk^2 = 122/50 = 2.44$.
3. Since B/Wk^2 is less than A, the allowable starts per hour = 2.44.

4. From Table 3, C = 58.
5. The minimum rest or "off time" between starts is therefore 58 seconds.

Table 4. Allowable Load Wk^2 (Squirrel-Cage Induction Motors)

HP	Synchronous Speed, RPM						
	3600	1800	1200	900	720	600	514
	Allowable Load Wk^2 (Exclusive of Motor Wk^2), $LB\text{-}FT^2$						
1	—	5.8	15	31	53	82	118
1.5	1.8	8.6	23	45	77	120	174
2	2.4	11	30	60	102	158	228
3	3.5	17	44	87	149	231	335
5	5.7	27	71	142	242	375	544
7.5	8.3	39	104	208	356	551	798
10	11	51	137	273	467	723	1048
15	16	75	200	400	685	1061	1538
20	21	99	262	525	898	1393	2018
25	26	122	324	647	1108	1719	2491
30	31	144	384	769	1316	2042	2959
40	40	189	503	1007	1725	2677	3881
50	49	232	620	1241	2127	3302	4788
60	58	275	735	1473	2524	3819	5680
75	71	338	904	1814	3111	4831	7010
100	92	441	1181	2372	4070	6320	9180
125	113	542	1452	2919	5010	7790	11310
150	133	640	1719	3456	5940	9230	—
200	172	831	2238	4508	7750	—	—
250	210	1017	2744	5540	—	—	—
300	246	1197	3239	—	—	—	—
350	281	1373	3723	—	—	—	—
400	315	1546	—	—	—	—	—
450	349	1714	—	—	—	—	—
500	381	1880	—	—	—	—	—

Reference: NEMA MG 1, Table 12-6.

The allowable Wk^2 is the moment of inertia of the load, referred to the motor shaft. The manufacturer of the driven machinery can usually provide the load Wk^2 value.

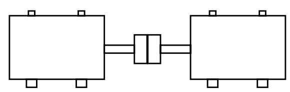
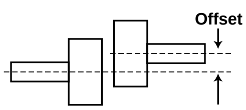
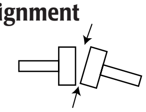
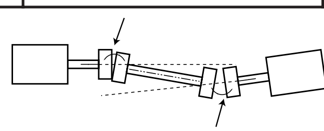
■ **Alternative Starting Methods.** Using a clutch to engage and disengage the drive allows the motor to continue running and eliminates the heat generated by a succession of starts. Starting devices such as solid-state or electromechanical reduced-voltage starters can reduce some stresses associated with motor starting. By doing so, they may help motors last longer. However, they generally don't increase the number of allowable starts per hour.

Adjustable-speed drives reduce mechanical stresses but usually increase the electrical and thermal stresses in motors. Harmonics generated by such drives are the primary cause of these stresses.

alignment and mechanical placement will reduce vibration, maximize bearing life, and increase the overall life of the motor and driven machine. To prevent frame distortion, increased vibration and reduced bearing life, correct for "soft foot" when mounting the motor.

■ **Suggested Alignment Tolerances.** Use dial indicators or laser systems to check the alignment of directly-coupled shafts. The following suggested alignment tolerances are the desired values, whether such values are zero or a targeted offset. Use them only if machinery manufacturer alignment tolerances are not available.

Table 5. Suggested Alignment Tolerances For Directly-Coupled Shafts

	RPM	Installation	In Service
Soft Foot (mils)*	All	±1.0	±1.5
Short Couplings 			
	RPM	**Installation**	**In Service**
Parallel Offset (mils) 	1200	±1.25	±2.0
	1800	±1.0	±1.5
	3600	±0.5	±0.75
Angular Misalignment (mils/inch)** 	1200	0.5	0.8
	1800	0.3	0.5
	3600	0.2	0.3
Couplings With Spacers 			
	RPM	**Installation**	**In Service**
Parallel Offset Per Inch of Spacer Length (mils/inch)	1200	0.9	1.5
	1800	0.6	1.0
	3600	0.3	0.5

* "Soft foot" describes the condition where the mounting feet are not all in the same plane. Measured in mils (1 mil. = .001 inches).

** To find the angular misalignment in mils/inch of coupling diameter, measure the widest opening in mils, then subtract the narrowest opening in mils, and divide by the diameter of the coupling in inches. (Note: Up and down motion of driving and driven shafts with temperature may be in either direction.)

Table 7. NEMA Frame Assignments

Three-Phase Open Motors–General Purpose

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

† When motors are to be used with V-belt or chain drives, the correct frame size is the one shown but with the suffix letter S omitted. For the corresponding shaft extension dimensions, see Pages 18-19.

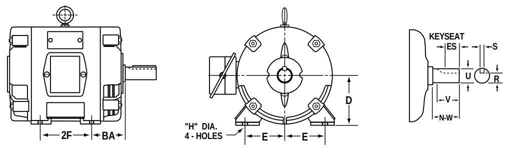
Table 8. NEMA Frame Assignments

Three-Phase TEFC Motors–General Purpose

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

† When motors are to be used with V-belt or chain drives, the correct frame size is the one shown but with the suffix letter S omitted. For the corresponding shaft extension dimensions, see Pages 18-19.

Table 9. NEMA Frame Dimensions* Foot-Mounted AC Machines



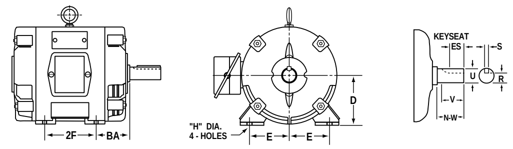
* Dimensions in inches

Frame Number	D	E	2F	BA	H**	U	N-W	V Min.	Keyseat R	Keyseat ES Min.	Keyseat S
42	2.62	1.75	1.69	2.06	0.28	0.3750	1.12		0.328		Flat
48	3.00	2.12	2.75	2.50	0.34	0.5000	1.50		0.453		Flat
48H	3.00	2.12	4.75	2.50	0.34	0.5000	1.50		0.453		Flat
56	3.50	2.44	3.00	2.75	0.34	0.6250	1.88		0.517	1.41	0.188
56H	3.50	2.44	5.00	2.75	0.34	0.6250	1.88		0.517	1.41	0.188
66	4.12	2.94	5.00	3.12	0.41	0.7500	2.25		0.644	1.91	0.188
143	3.50	2.75	4.00	2.25	0.34	0.7500	2.00	1.75	0.644	1.41	0.188
143T	3.50	2.75	4.00	2.25	0.34	0.8750	2.25	2.00	0.771	1.41	0.188
145	3.50	2.75	5.00	2.25	0.34	0.7500	2.00	1.75	0.644	1.41	0.188
145T	3.50	2.75	5.00	2.25	0.34	0.8750	2.25	2.00	0.771	1.41	0.188
182	4.50	3.75	4.50	2.75	0.41	0.8750	2.25	2.00	0.771	1.41	0.188
182T	4.50	3.75	4.50	2.75	0.41	1.1250	2.75	2.50	0.986	1.78	0.250
184	4.50	3.75	5.50	2.75	0.41	0.8750	2.25	2.00	0.771	1.41	0.188
184T	4.50	3.75	5.50	2.75	0.41	1.1250	2.75	2.50	0.986	1.78	0.250
203	5.00	4.00	5.50	3.12	0.41	0.7500	2.25	2.00	0.644	1.53	0.188
204	5.00	4.00	6.50	3.12	0.41	0.7500	2.25	2.00	0.644	1.53	0.188
213	5.25	4.25	5.50	3.50	0.41	1.1250	3.00	2.75	0.986	2.03	0.250
213T	5.25	4.25	5.50	3.50	0.41	1.3750	3.38	3.12	1.201	2.41	0.312
215	5.25	4.25	7.00	3.50	0.41	1.1250	3.00	2.75	0.986	2.03	0.250
215T	5.25	4.25	7.00	3.50	0.41	1.3750	3.38	3.12	1.201	2.41	0.312
224	5.50	4.50	6.75	3.50	0.41	1.0000	3.00	2.75	0.859	2.03	0.250
225	5.50	4.50	7.50	3.50	0.41	1.0000	3.00	2.75	0.859	2.03	0.250
254	6.25	5.00	8.25	4.25	0.53	1.1250	3.38	3.12	0.986	2.03	0.250
254U	6.25	5.00	8.25	4.25	0.53	1.3750	3.75	3.50	1.201	2.78	0.312
254T	6.25	5.00	8.25	4.25	0.53	1.625	4.00	3.75	1.416	2.91	0.375
256U	6.25	5.00	10.00	4.25	0.53	1.3750	3.75	3.50	1.201	2.78	0.312
256T	6.25	5.00	10.00	4.25	0.53	1.625	4.00	3.75	1.416	2.91	0.375
284	7.00	5.50	9.50	4.75	0.53	1.2500	3.75	3.50	1.112	2.03	0.250
284U	7.00	5.50	9.50	4.75	0.53	1.625	4.88	4.62	1.416	3.78	0.375
284T	7.00	5.50	9.50	4.75	0.53	1.875	4.62	4.38	1.591	3.28	0.500
284TS	7.00	5.50	9.50	4.75	0.53	1.625	3.25	3.00	1.416	1.91	0.375
286U	7.00	5.50	11.00	4.75	0.53	1.625	4.88	4.62	1.416	3.78	0.375
286T	7.00	5.50	11.00	4.75	0.53	1.875	4.62	4.38	1.591	3.28	0.500
286TS	7.00	5.50	11.00	4.75	0.53	1.625	3.25	3.00	1.416	1.91	0.375
324	8.00	6.25	10.50	5.25	0.66	1.625	4.88	4.62	1.416	3.78	0.375
324U	8.00	6.25	10.50	5.25	0.66	1.875	5.62	5.38	1.591	4.28	0.500
324S	8.00	6.25	10.50	5.25	0.66	1.625	3.25	3.00	1.416	1.91	0.375
324T	8.00	6.25	10.50	5.25	0.66	2.125	5.25	5.00	1.845	3.91	0.500
324TS	8.00	6.25	10.50	5.25	0.66	1.875	3.75	3.50	1.591	2.03	0.500
326	8.00	6.25	12.00	5.25	0.66	1.625	4.88	4.62	1.416	3.78	0.375
326U	8.00	6.25	12.00	5.25	0.66	1.875	5.62	5.38	1.591	4.28	0.500
326S	8.00	6.25	12.00	5.25	0.66	1.625	3.25	3.00	1.416	1.91	0.375
326T	8.00	6.25	12.00	5.25	0.66	2.125	5.25	5.00	1.845	3.91	0.500
326TS	8.00	6.25	12.00	5.25	0.66	1.875	3.75	3.50	1.591	2.03	0.500

Reference: NEMA Standards MG 1-1998, 4.4.1.

**Frames 42 to 66, inclusive: the H dimension is Width of Slot. Frames 143 to 505S, inclusive: the H dimension is Diameter of Hole.

Table 9. NEMA Frame Dimensions*
Foot-Mounted AC Machines—Continued



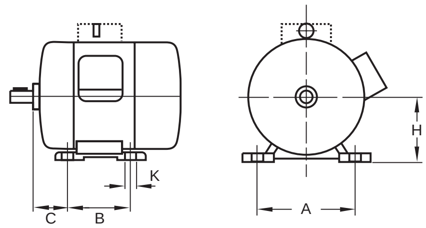
* Dimensions in inches

Frame Number	D	E	2F	BA	H**	U	N-W	V Min.	Keyseat		
									R	ES Min.	S
364	9.00	7.00	11.25	5.88	0.66	1.875	5.62	5.38	1.591	4.28	0.500
364S	9.00	7.00	11.25	5.88	0.66	1.625	3.25	3.00	1.416	1.91	0.375
364U	9.00	7.00	11.25	5.88	0.66	2.125	6.38	6.12	1.845	5.03	0.500
364US	9.00	7.00	11.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
364T	9.00	7.00	11.25	5.88	0.66	2.375	5.88	5.62	2.021	4.28	0.625
364TS	9.00	7.00	11.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
365	9.00	7.00	12.25	5.88	0.66	1.875	5.62	5.38	1.591	4.28	0.500
365S	9.00	7.00	12.25	5.88	0.66	1.625	3.25	3.00	1.416	1.91	0.375
365U	9.00	7.00	12.25	5.88	0.66	2.125	6.38	6.12	1.845	5.03	0.500
365US	9.00	7.00	12.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
365T	9.00	7.00	12.25	5.88	0.66	2.375	5.88	5.62	2.021	4.28	0.625
365TS	9.00	7.00	12.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
404	10.00	8.00	12.25	6.62	0.81	2.125	6.38	6.12	1.845	5.03	0.500
404S	10.00	8.00	12.25	6.62	0.81	1.875	3.75	3.50	1.591	2.03	0.500
404U	10.00	8.00	12.25	6.62	0.81	2.375	7.12	6.88	2.021	5.53	0.625
404US	10.00	8.00	12.25	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
404T	10.00	8.00	12.25	6.62	0.81	2.875	7.25	7.00	2.450	5.65	0.750
404TS	10.00	8.00	12.25	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
405	10.00	8.00	13.75	6.62	0.81	2.125	6.38	6.12	1.845	5.03	0.500
405S	10.00	8.00	13.75	6.62	0.81	1.875	3.75	3.50	1.591	2.03	0.500
405U	10.00	8.00	13.75	6.62	0.81	2.375	7.12	6.88	2.021	5.53	0.625
405US	10.00	8.00	13.75	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
405T	10.00	8.00	13.75	6.62	0.81	2.875	7.25	7.00	2.450	5.65	0.750
405TS	10.00	8.00	13.75	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
444	11.00	9.00	14.50	7.50	0.81	2.375	7.12	6.88	2.021	5.53	0.625
444S	11.00	9.00	14.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
444U	11.00	9.00	14.50	7.50	0.81	2.875	8.62	8.38	2.450	7.03	0.750
444US	11.00	9.00	14.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
444T	11.00	9.00	14.50	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
444TS	11.00	9.00	14.50	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
445	11.00	9.00	16.50	7.50	0.81	2.375	7.12	6.88	2.021	5.53	0.625
445S	11.00	9.00	16.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
445U	11.00	9.00	16.50	7.50	0.81	2.875	8.62	8.38	2.450	7.03	0.750
445US	11.00	9.00	16.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
445T	11.00	9.00	16.50	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
445TS	11.00	9.00	16.50	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
447T	11.00	9.00	20.00	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
447TS	11.00	9.00	20.00	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
449T	11.00	9.00	25.00	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
449TS	11.00	9.00	25.00	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
504U	12.50	10.00	16.00	8.50	0.94	2.875	8.62	8.38	2.450	7.28	0.750
504S	12.50	10.00	16.00	8.50	0.94	2.125	4.25	4.00	1.845	2.78	0.500
505	12.50	10.00	18.00	8.50	0.94	2.875	8.62	8.38	2.450	7.28	0.750
505S	12.50	10.00	18.00	8.50	0.94	2.125	4.25	4.00	1.845	2.78	0.500

Reference: NEMA Standards MG 1-1998, 4.4.1.

** Frames 42 to 66, inclusive: the H dimension is Width of Slot. Frames 143 to 505S, inclusive: the H dimension is Diameter of Hole.

Table 10. IEC Mounting Dimensions*
Foot-Mounted AC and DC Machines



Frame Number	H	A	B	C	K	Bolt or Screw
56 M	2.20	3.55	2.80	1.40	0.23	M5
63 M	2.48	3.95	3.15	1.55	0.28	M6
71 M	2.79	4.40	3.55	1.75	0.28	M6
80 M	3.14	4.90	3.95	1.95	0.40	M8
90 S	3.54	5.50	3.95	2.20	0.40	M8
90 L	3.54	5.50	4.90	2.20	0.40	M8
100 S	3.93	6.30	4.40	2.50	0.48	M10
100 L	3.93	6.30	5.50	2.50	0.48	M10
112 S	4.40	7.50	4.50	2.75	0.48	M10
112 M	4.40	7.50	5.50	2.75	0.48	M10
132 S	5.19	8.50	5.50	3.50	0.48	M10
132 M	5.19	8.50	7.00	3.50	0.48	M10
160 S	6.29	10.00	7.00	4.25	0.58	M12
160 M	6.29	10.00	8.25	4.25	0.58	M12
160 L	6.29	10.00	10.00	4.25	0.58	M12
180 S	7.08	11.00	8.00	4.75	0.58	M12
180 M	7.08	11.00	9.50	4.75	0.58	M12
180 L	7.08	11.00	11.00	4.75	0.58	M12
200 S	7.87	12.50	9.00	5.25	0.73	M16
200 M	7.87	12.50	10.50	5.25	0.73	M16
200 L	7.87	12.50	12.00	5.25	0.73	M16
225 S	8.85	14.00	11.25	5.85	0.73	M16
225 M	8.85	14.00	12.25	5.85	0.73	M16
250 S	9.84	16.00	12.25	6.60	0.95	M20
250 M	9.84	16.00	13.75	6.60	0.95	M20
280 S	11.02	18.00	14.50	7.50	0.95	M20
280 M	11.02	18.00	16.50	7.50	0.95	M20
315 S	12.40	20.00	16.00	8.50	1.11	M24
315 M	12.40	20.00	18.00	8.50	1.11	M24
355 S	13.97	24.00	19.70	10.00	1.11	M24
355 M	13.97	24.00	22.05	10.00	1.11	M24
355 L	13.97	24.00	24.80	10.00	1.11	M24
400 S	15.74	27.00	22.05	11.00	1.38	M30
400 M	15.74	27.00	24.80	11.00	1.38	M30
400 L	15.74	27.00	27.95	11.00	1.38	M30

Reference: IEC 72-1 Standards.

* Dimensions, except for bolt and screw sizes, are shown in inches (rounded off). Bolt and screw sizes are shown in millimeters.

For tolerances on dimensions, see IEC 72-1, 6.1, Foot-Mounted Machines, Table 1. (Note: Data in IEC tables is shown in millimeters.)

Glossary

Ambient temperature–The temperature of the surrounding cooling medium. Commonly known as room temperature when the air is the cooling medium in contact with the equipment.

Base line–A measurement taken when a machine is in good operating condition that is used as a reference for monitoring and analysis.

Breakdown torque–The maximum torque that an AC motor will develop with rated voltage applied at rated frequency without an abrupt drop in speed. Also termed pull-out torque or maximum torque.

Efficiency–The ratio between useful work performed and the energy expended in producing it. It is the ratio of output power divided by the input power.

Full-load speed–The speed at which any rotating machine produces its rated output.

Full-load torque–The torque required to produce rated power at full-load speed.

General purpose motor–AC induction motor of 500 horsepower or less, open or enclosed construction, continuous duty, designed in standard ratings with standard characteristics for use under service conditions without restriction to a particular application (see NEMA MG 1-1998, 1.6.1).

Hertz (Hz)–The preferred terminology for cycles per second (frequency).

Horsepower–A unit for measuring the power of motors or the rate of doing work. One horsepower equals 33,000 foot-pounds of work per minute (550 ft•lbs per second) or 746 watts.

Insulation–Nonconducting materials separating the current-carrying parts of an electric machine from each other or from adjacent conducting material at a different potential.

Kilowatt (kW)–A unit of electrical power. Also, the output rating of motors manufactured and used off the North American continent.

Locked-rotor current–Steady-state current taken from the line with the rotor at standstill and at a rated voltage and frequency.

Locked-rotor torque–The minimum torque that a motor will develop at standstill for all angular positions of the rotor with rated voltage applied at rated frequency.

Megohmmeter–An instrument for measuring insulation resistance.

NEMA–National Electrical Manufacturers Association.

Poles–The magnetic poles set up inside an electric machine by the placement and connection of the windings.

Rated temperature rise–The permissible rise in temperature above ambient for an electric machine operating under load.

Rotor–The rotating element of any motor or generator.

Slip—The difference between synchronous and operating speeds, compared to synchronous speed, expressed as a percentage. Also the difference between synchronous and operating speeds, expressed in rpm.

Soft foot—The condition where the mounting feet of a motor and the pads of the base are not all in the same plane.

Stator—The stationary part of a rotating electric machine. Commonly used to describe the stationary part of an AC machine that contains the power windings.

Synchronous speed—The speed of the rotating machine element of an AC motor that matches the speed of the rotating magnetic field created by the armature winding.

$$\text{Synchronous speed} = (\text{Frequency} \times 120)/(\text{Number of poles})$$

Torque—The rotating force produced by a motor. The units of torque may be expressed as pound-foot, pound-inch (English system), or newton-meter (metric system).

Trending—Analysis of the change in measured data over at least three data measurement intervals.

References

A Guide To AC Motor Repair And Replacement. Electrical Apparatus Service Association, Inc. St. Louis, MO, 1997.

ANSI/EASA Standard AR100-1998 Recommended Practice for the Repair of Rotating Electrical Apparatus. Electrical Apparatus Service Association, Inc. St. Louis, MO, 1998.

Electrical Engineering Pocket Handbook. Electrical Apparatus Service Association, Inc. St. Louis, MO, 1997-2000.

IEEE Standard 112-1996: Standard Test Procedure For Polyphase Induction Motors And Generators. Institute of Electrical and Electronics Engineers. New York, NY, 1991.

IEC 72-1: Dimensions And Output Series For Rotating Electrical Machines; Part 1. International Electrotechnical Commission. Geneva, Switzerland, 1997.

Mechanical Reference Handbook. Electrical Apparatus Service Association, Inc. St. Louis, MO, 1999.

NEMA Standards MG 1-1998. National Electrical Manufacturers Association. Rosslyn, VA, 1999.

NEMA Standards MG 10-1994. National Electrical Manufacturers Association. Rosslyn, VA, 1994.

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