FAN ENGINEERING

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INFORMATION AND RECOMMENDATIONS FOR THE ENGINEER

FE-1800

Application Guide for Selecting AC Motors Capable of Overcoming Fan Inertia

Introduction

Bringing a fan up to speed is not difficult as long as enough torque is available in the motor to do it in a reasonable amount of time. The question is, how much torque is enough to allow it to accelerate the fan to full speed while also protecting the motor against continuous overload?

This document outlines the methodology that is commonly used in calculating the motor starting time. Most of the data necessary for these calculations comes from the motor manufacturer with the exception of the fan inertia (WR^2) and the fan brake horsepower (bhp), which are supplied by the fan manufacturer.

Information from the motor manufacturer includes a speed torque curve plotted in percent of full load torque and percent of synchronous speed, full load torque, full load speed, WK^2 of the motor rotor and an amps vs. speed curve plotted as a percent of full load amps.

Torque and Horsepower

Torque is the turning effort or force acting through some radius causing it to turn at a constant rate. In other words, if it takes a one pound (lb) force applied at a one foot (ft) radius from a shaft centerline to rotate it at a constant rate, we say the torque is one pound times one foot or one pound-foot (lb-ft).

Horsepower on the other hand is a measure of how fast the shaft turns. The higher the shaft speed the higher the horsepower. By definition one horsepower equals 33,000 lb-ft/min.

Therefore, in one revolution the one pound force moves a distance of 2π feet. The work done is then 2π feet x 1 pound force or 2π lb-ft. Thus, to produce one horsepower we would have to turn the shaft at the rate of:

$$\text{(1)} \quad \frac{1 \text{ hp} \times 33{,}000 \text{ lb-ft/min}}{2\pi \text{ lb-ft/revolution}} = 5252 \text{ rpm}$$

From this example we can derive a formula for determining horsepower from speed and torque.

$$\text{(2)} \quad \text{hp} = \frac{\text{rpm} \times \text{torque}}{5252}$$

$$\text{(3) By transposition:} \quad \text{torque} = \frac{\text{hp} \times 5252}{\text{rpm}}$$

During starting time it is assumed that the fan system does not change. Therefore, the fan design load torque is based on the above formula and by fan laws the fan torque for any other speed is calculated from:

$$\text{(4)} \quad \text{torque}_X = \text{full speed torque} \left(\frac{\text{rpm}_X}{\text{rpm}_{FS}}\right)^2$$

Referring Fan Inertia (WR^2) to Motor Inertia (WK^2)

The motor must not only develop sufficient torque to overcome the fan load, but it must have enough excess torque to overcome the inertia of the fan and accelerate it to speed within a required amount of time. Since our concern is with the power required at the motor, all components must be referred to a common base. Using the motor rotational speed as this base, the load inertia referred to the motor speed can be calculated as follows:

$$\text{(5)} \quad WR^2_{ms} = WR^2_{fs}\left(\frac{N_f}{N_m}\right)^2$$

Where: WR^2_{ms} = Inertia of fan load (lb-ft^2) referred to motor speed (sometimes referred to as WK^2 by motor manufacturers)
WR^2_{fs} = Inertia of fan load plus drives, etc. (lb-ft^2)
N_f = Speed of fan (rpm)
N_m = Speed of motor (rpm)

Note that the ratio $(N_f/N_m)^2$ reflects the fan inertia to the motor. A reduction in speed between motor and fan reduces the effect of load inertia on accelerating torque; conversely, an increase in speed between motor and fan increases the accelerating torque required. Obviously then, for direct connected fans, this ratio becomes one, simplifying the calculation.

Inertia can be defined as the characteristic of an object at rest to remain at rest and when in motion to remain in motion.

The term WR^2 denotes the amount of inertia possessed by an object that rotates about an axis.

Where: W = Weight of the object in pounds (lb)
R = Radius of gyration of the object in feet (ft)

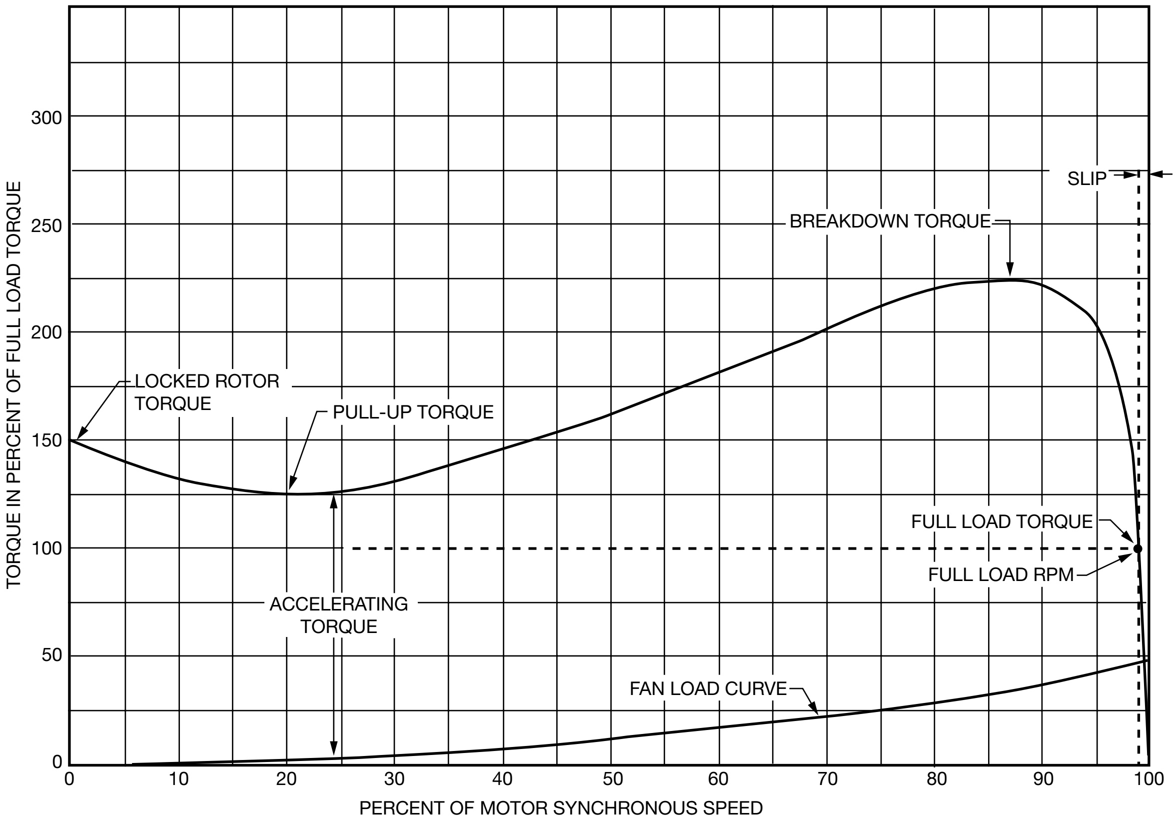
Acceleration Time

If we had a constant torque (T) available to accelerate the fan load from rpm_1 to rpm_2 the time (t) in seconds would be:

$$\text{(6)} \quad t = \frac{WR^2 \times (\text{rpm}_2 - \text{rpm}_1)}{308T}$$

Actually the torque (T) available to accelerate the fan load is the difference between motor torque and the torque required for the fan. This torque is constantly changing throughout the starting cycle (see Figure 1). If we take small enough increments of speed throughout the cycle then the available torque for acceleration can be considered as a constant through this increment and the above formula can be used to calculate the time required to go through each speed increment.

Figure 1. Typical TEFC Motor Performance Curve,
60 HP Design "B", FLT = 177 lb-ft, 1800 Synchronous RPM, 1780 Full Load RPM



The torque supplied by the motor also varies during starting. A typical motor speed torque curve is shown in Figure 1. Certain locations on the speed torque curve have defined positions and are described as follows:

Locked Rotor Torque — Locked rotor torque is the torque that the motor will develop at rest with rated voltage and frequency applied. It is sometimes called starting torque and is usually expressed as a percent of full load torque.

Pull-Up Torque — Pull-up torque is the minimum torque developed during the period of acceleration from locked rotor to the speed at which breakdown occurs. It is usually expressed as a percent of full load torque.

Breakdown Torque — Breakdown torque is the maximum torque the motor will develop, with rated voltage and frequency applied, without an abrupt drop in speed. It is usually expressed as a percent of full load torque.

Full Load Torque — Full load torque is the torque necessary for the motor to produce its rated horsepower at full load speed. In lb-ft it is equal to the rated horsepower times 5252 divided by the full load speed in rpm.

NOTE: The values given in Figure 1 vary by motor size, by motor type and by manufacturer. In addition, motors draw large currents during starting. This may "pull down" the supply voltage and the motor may not supply its full rated torque.

Accelerating Torque

Accelerating torque is the difference between the motor speed torque curve and the fan load curve. This is the torque available to bring the fan up to speed.

As important as it is to bring the fan up to speed, it is equally important to bring it up to speed as quickly as possible to prevent excessive motor temperature rise. Generally speaking, if motor frame sizes 143T through 286T come up to speed in 10 seconds, 12 seconds for frame sizes 324T through 326T and 15 seconds for frame sizes 364T through 445T, they should be acceptable. Times increase with increasing frame size because the larger frames are more able to act as heat sinks for the excess energy of startup.

Starting circuits that allow the motor to draw its high starting amps without prematurely tripping must be used.

Example 1.

Given:

1. Fan: Size 55 backward inclined airfoil impeller Class II, 835 rpm, 56 bhp
2337 lb-ft^2 = WR^2 of the impeller
0.75 lb-ft^2 = WR^2 of the shaft

Example 1 (continued)

2. Motor:
   60 hp, 1780 full load rpm, TEFC, 364T frame
   177 lb-ft full load torque
   10.5 lb-ft^2 = WK^2 of the rotor
   Test data listed in columns 1, 2, 4, 5 in Table 1

3. Drives:
   Motor – 6B groove, 7.3 PD sheave = 1.2 lb-ft^2 (WR^2) drive catalog
   Fan – 6B groove, 15.7 PD sheave = 11.9 lb-ft^2 (WR^2) drive catalog
   6B116 belts = 8.4 lb
   Belt WR^2 = 8.4 x [7.3 ÷ (12 x 2)]^2 = 0.78 lb-ft^2

4. WR^2 Summary:

Part	WR^2 (lb-ft^2)	referred to motor WK^2 (lb-ft^2)
Fan Impeller	2237.00	492.26
Fan Shaft	0.75	0.17
Fan Sheave	11.90	2.62
Motor Sheave	1.20	1.20
Motor Rotor	10.50	10.50
Belts	0.78	0.78
		507.33 lb-ft^2

Starting Time

Find the start time in seconds, using the formulas from this document and the motor data listed in Table 1.

The calculations indicate it would require 12.68 seconds to bring this fan load up to speed, which is less than the general recommendation of 15 seconds for this motor and well below the 23 seconds (maximum) listed by the manufacturer of this particular motor.

As mentioned, every effort should be made to obtain the actual motor speed torque curve and the allowable starting time from the manufacturer for best results. In lieu of that, motor speed torque curves can be approximated using minimum values of locked rotor, breakdown and pull-up torque as listed in the NEMA motor specification guide.

For convenience we have listed these values for Design B, 50 Hz and 60 Hz, single speed polyphase squirrel cage motors in Tables 2, 3 and 4, respectively. All values are expressed in percent of full load torque.

Table 1. Starting Time Calculations

PERCENT OF SYNCHRONOUS RPM	PERCENT OF FLT	MOTOR RPM	MOTOR TORQUE (LB-FT)	FAN LOAD TORQUE (LB-FT)	ACCELERATING TORQUE (LB-FT)	AVG. ACCEL. TORQUE (LB-FT)	STARTING TIME (SEC.)
0	150	0	266	0	266.0	0	0
5	140	90	248	0.4	247.6	257	0.577
10	132	180	234	1.7	232.3	240	0.618
15	127	270	225	3.8	221.2	227	0.653
20	125	360	221	6.8	214.2	218	0.680
25	127	450	225	10.6	214.4	214	0.693
30	132	540	234	15.2	218.8	217	0.683
35	139	630	246	20.7	225.3	222	0.668
40	146	720	258	27.0	231.0	228	0.650
45	154	810	273	34.2	238.8	235	0.631
50	163	900	289	42.2	246.8	243	0.610
55	172	990	304	51.1	252.9	250	0.593
60	182	1080	322	60.8	261.2	257	0.577
65	191	1170	338	71.4	266.6	264	0.562
70	201	1260	356	82.8	273.2	270	0.549
75	211	1350	373	95.0	278.0	276	0.537
80	219	1440	388	108.1	279.9	279	0.532
85	224	1530	396	122.0	274.0	277	0.535
90	223	1620	395	136.8	258.2	266	0.558
92	219	1656	388	143.0	245.0	252	0.235
94	209	1692	370	149.2	220.2	233	0.255
96	190	1728	336	155.7	180.3	201	0.295
98	140	1764	248	162.2	85.8	133	0.466
98.9	100	1780	177	165.2	11.8	49	0.538

Total Starting Time = 12.675

Table 1 (continued)

Column 1: Arbitrary percent of synchronous rpm values selected to adequately cover the speed torque curve shown in Figure 1.

Column 2: Corresponding percent of full torque values from the same speed torque curve.

Column 3: Values of motor rpm corresponding to Column 1.

$$\frac{\text{Column 1 x Synchronous RPM}}{100}$$

Column 4: Values of motor torque (lb-ft) corresponding to Column 2.

$$\frac{\text{Column 2 x Full Load Torque (FLT)}}{100}$$

Column 5: Values of equivalent fan load torque (lb-ft) referred to the motor.

$$\left(\frac{\text{Column 1}}{\text{Motor Full Load Speed}}\right)^2 \text{x} \frac{\text{Fan bhp x 5250}}{\text{Motor Full Load Speed}}$$

(formula 4)

Column 6: Available accelerating torque (lb-ft) for each percent increment.

Column 4 – Column 5

Column 7: Average accelerating torque (lb-ft) from one speed to the next.

$$\frac{\text{Column 6 Line 1 + Column 6 Line 2,}}{2}$$

$$\frac{\text{Column 6 Line 2 + Column 6, Line 3}}{2}$$

etc.

Column 8: Calculate values of time (t) seconds for each speed increment using formula (6). Add these values to obtain the total starting time.

$$t = \frac{WR^2 \text{ Referred to Motor x (Column 3 Line 2 - Column 3 Line 1)}}{\text{308 x Column 7 Line 2}}$$

Table 2. Locked-Rotor Torque of Design A & B, 60 & 50 Hertz
Single-Speed Polyphase Squirrel-Cage Medium Motors
Minimum Values Expressed as a Percent of Full Load Torque

		SYNCHRONOUS SPEED, RPM					
HP	**60 HERTZ** **50 HERTZ**	**3600** **3000**	**1800** **1500**	**1200** **1000**	**900** **750**	**720** **—**	**600** **—**
1/2		—	—	—	140	140	115
3/4		—	—	175	135	135	115
1		—	275	170	135	135	115
1½		175	250	165	130	130	115
2		170	235	160	130	125	115
3		160	215	155	130	125	115
5		150	185	150	130	125	115
7½		140	175	150	125	120	115
10		135	165	150	125	120	115
15		130	160	140	125	120	115
20		130	150	135	125	120	115
25		130	150	135	125	120	115
30		130	150	135	125	120	115
40		125	140	135	125	120	115
50		120	140	135	125	120	115
60		120	140	135	125	120	115
75		105	140	135	125	120	115
100		105	125	125	125	120	115
125		100	110	125	120	115	115
150		100	110	120	120	115	115
200		100	100	120	120	115	—
250		70	80	100	100	—	—
300		70	80	100	—	—	—
350		70	80	100	—	—	—
400		70	80	—	—	—	—
450		70	80	—	—	—	—

Table 3. Breakdown Torque of Design A & B, 60 & 50 Hertz
Single-Speed Polyphase Squirrel-Cage Medium Motors
Minimum Values Expressed as a Percent of Full Load Torque

SYNCHRONOUS SPEED, RPM							
HP	**60 HERTZ**	**3600**	**1800**	**1200**	**900**	**720**	**600**
	50 HERTZ	**3000**	**1500**	**1000**	**750**	**—**	**—**
1/2		—	—	—	225	200	200
3/4		—	—	275	220	200	200
1		—	300	265	215	200	200
1½		250	280	250	210	200	200
2		240	270	240	210	200	200
3		230	250	230	205	200	200
5		215	225	215	205	200	200
7½		200	215	205	200	200	200
10 to 125		200	200	200	200	200	200
150		200	200	200	200	200	—
200		200	200	200	200	200	—
250		175	175	175	175	—	—
300 to 350		175	175	175	—	—	—
400 to 500		175	175	—	—	—	—

Table 4. Pull-Up Torque of Design A & B, 60 & 50 Hertz
Single-Speed Polyphase Squirrel-Cage Medium Motors
Minimum Values Expressed as a Percent of Full Load Torque

SYNCHRONOUS SPEED, RPM							
HP	**60 HERTZ**	**3600**	**1800**	**1200**	**900**	**720**	**600**
	50 HERTZ	**3000**	**1500**	**1000**	**750**	**—**	**—**
1/2		—	—	—	100	100	100
3/4		—	—	120	100	100	100
1		—	190	120	100	100	100
1½		120	175	115	100	100	100
2		120	165	110	100	100	100
3		110	150	110	100	100	100
5		105	130	105	100	100	100
7½		100	120	105	100	100	100
10		100	115	105	100	100	100
15		100	110	100	100	100	100
20		100	105	100	100	100	100
25		100	105	100	100	100	100
30		100	105	100	100	100	100
40		100	100	100	100	100	100
50		100	100	100	100	100	100
60		100	100	100	100	100	100
75		95	100	100	100	100	100
100		95	100	100	100	100	100
125		90	100	100	100	100	100
150		90	100	100	100	100	100
200		90	90	100	100	100	—
250		65	75	90	90	—	—
300		65	75	90	—	—	—
350		65	75	90	—	—	—
400		65	75	—	—	—	—
450		65	75	—	—	—	—

Alternate Selection Techniques

To quickly determine if the motor is capable of accelerating the fan load up to speed, compare the fan load inertia (WR^2) referred to the motor speed (WK^2) against the motor manufacturer's published load WK^2, exclusive of motor WK^2, in lb-ft^2.

Example 2:
From Example 1, the WR^2 of the fan impeller is 2237 lb-ft^2. This can usually be obtained from the fan catalog. It is good practice to add ten percent to the impeller inertia to allow for the inertia of the belts, shaft, sheaves and/or drive system.

$$\frac{2237 \text{ lb-ft}^2 \text{ x } 10}{100} = 223.7 \text{ lb-ft}^2$$

Fan load inertia:

$$2237 \text{ lb-ft}^2 + 223.7 \text{ lb-ft}^2 = 2460.7 \text{ lb-ft}^2$$

From formula (5) fan load inertia referred to motor speed =

$$2460.7 \text{ x} \left(\frac{835}{1780}\right)^2 = 541.5 \text{ lb-ft}^2$$

As long as this value is equal to or less than the fan type load WK^2 as published by the motor manufacturer, then the motor should be capable of accelerating the fan.

From Table 6 we see that a 60 HP, TEFC, Brand A motor is capable of accelerating a fan load of 835 WK^2. This particular motor would work fine; however, a similar motor from another manufacturer may be marginal or not work at all, requiring either a larger motor or a lighter impeller.

It's important to know the actual WK^2 capability of the specific motor used. However, where the specific WK^2 values are not obtainable, certain "rules of thumb" values may be used, which if not exceeded, should be suitable for most manufacturers' TEFC motors. These "rules of thumb" values are as follows:

(7) $WK^2 = 2.25$ x motor hp (2 pole or 3600 rpm motors)

(8) $WK^2 = 13.5$ x motor hp (4 pole or 1800 rpm motors)

(9) $WK^2 = 37.5$ x motor hp (6 pole or 1200 rpm motors)

(10) $WK^2 = 80.0$ x motor hp (8 pole or 900 rpm motors)

CAUTION: These are rule of thumb values. If selection is marginal use specific WK^2 values for the motor in question.

Approximate Acceleration Time

Generally speaking, if three phase, normal torque, normal starting current motors built in frame sizes 447T or smaller can accelerate up to speed in less than 20 seconds, they should be acceptable for fan duty providing they are started across the line at rated voltage with the motor at ambient temperatures.

The acceleration time can be approximated from the following formula:

(11)
$$t = \frac{(WR_{ms})^2 (Nm)}{308 \text{ Ta}}$$

Where: t = Acceleration time (sec.)
WR^2_{ms} = Inertia of fan load (lb-ft^2) referred to motor speed
N_m = Speed of motor (rpm)
Ta = Accelerating torque (lb-ft) – Use 1.5 x motor FLT

Example 3:
From Example 2, WR^2_{ms} = 541.5 lb-ft^2, Nm= 1780 rpm and FLT = 177 lb-ft

$$t = \frac{541.5 \text{ x } 1780}{308 \text{ x } 177 \text{ x } 1.5} = 11.79 \text{ seconds}$$

Frequency of Starting

The calculations in the preceding discussion are based on a maximum of two starts per hour at ambient temperature or one start at running temperature. It's also assumed that the motors will be started across-the-line at full nameplate voltage. Deviation from this can seriously affect a motor's WR^2 capability and its ability to accelerate the load within a given time frame.

Tables 5 and 6 list the maximum inertia limits (WK^2) for various motor manufacturers' ODP and TEFC motors, compared to the recommended minimum values as listed in the NEMA motor specification guide.

From these tables **it can be seen that a large WK^2 variance can occur between manufacturers. Therefore, we cannot stress too strongly the importance of obtaining the correct WK^2 for the specific motor in question**, particularly when the fan WR^2 closely approaches the WK^2 values listed.

For the majority of fan applications encountered, motor selection based on fan brake horsepower is all that is required. There are, however, certain applications to be on the lookout for where the minimum motor horsepower may not be adequate to accelerate the fan load. Potential problem applications are:

1. Direct connected fans involving heavy impellers, primarily steel.
2. Speed-up drives involving any type of impeller.
3. Slow-down drives involving low horsepower and heavy impellers, such as steel DWDI fans.

For Cases 1 and 2, it may be necessary to use a larger motor than that required for the fan bhp. For Case 3, going to a motor with more poles will often solve the problem.

While it is important to consider all applications, it is particularly important to review each application of the types listed above.

Table 5. Maximum Inertial Limits (WK^2) for Three Phase Standard Design B ODP Motors

MOTOR HP	**2-POLE 3600 RPM ODP**					
	NEMA MIN. WK^2	**MOTOR MANUFACTURER**				
		A	**B**	**C**	**D**	**E**
1	—	9	—	—	—	—
1½	1.8	11	—	6	4.2	5.8
2	2.4	13	—	9	4.5	6
3	3.5	16	—	9	5	7
5	5.7	23	—	8	8	13
7½	8.3	29	—	13	13	12
10	11	40	—	9	20	15
15	16	60	28	11	30	18
20	21	77	29	15	45	37
25	26	91	45	68	55	38
30	31	118	51	64	65	54
40	40	143	67	86	85	51
50	49	203	81	125	120	82
60	58	246	159	135	155	82
75	71	296	112	110	200	100
100	92	417	183	140	250	126
125	113	484	197	130	240	144
150	133	—	325	170	280	155
200	172	—	—	280	370	—
250	210	—	—	330	450	—
300	246	—	—	550	515	—

MOTOR HP	**4-POLE 1800 RPM ODP**					
	NEMA MIN. WK^2	**MOTOR MANUFACTURER**				
		A	**B**	**C**	**D**	**E**
1	5.8	29	—	7	12	39
1½	8.6	35	—	20	17	38
2	11	50	—	20	23	35
3	17	74	—	39	35	67
5	27	98	—	49	55	70
7½	39	144	—	70	80	82
10	51	184	—	95	105	95
15	75	260	97	93	200	152
20	99	339	136	255	250	161
25	122	406	185	290	305	179
30	144	501	234	365	375	202
40	189	581	327	485	480	264
50	232	743	472	585	580	284
60	275	880	552	510	650	364
75	338	1127	691	780	790	420
100	441	1461	907	1050	920	669
125	542	1878	1086	1350	1170	762
150	640	—	1297	1630	1350	—
200	831	—	1695	2190	1740	—
250	1017	—	1570	2060	2130	—
300	1197	—	—	2510	2510	—

MOTOR HP	**6-POLE 1200 RPM ODP**					
	NEMA MIN. WK^2	**MOTOR MANUFACTURER**				
		A	**B**	**C**	**D**	**E**
1	15	58	—	53	24	98
1½	23	84	—	40	45	160
2	30	109	—	52	60	169
3	44	140	—	107	85	216
5	71	210	—	140	145	248
7½	104	294	—	275	230	267
10	137	397	—	400	310	316
15	200	560	182	530	460	429
20	262	751	264	745	610	473
25	324	872	379	825	770	544
30	384	1144	437	885	920	577
40	503	1342	777	1050	1200	942
50	620	1682	846	1290	1520	1074
60	735	2409	1122	1850	1630	1248
75	904	2703	1380	2360	2000	1317
100	1181	3546	2003	3350	2600	—
125	1452	4485	2399	3700	3190	—
150	1719	—	—	3800	3780	—
200	2238	—	—	5830	4900	—
250	2744	—	—	6880	5590	—
300	3239	—	—	—	5200	—

MOTOR HP	**8-POLE 900 RPM ODP**					
	NEMA MIN. WK^2	**MOTOR MANUFACTURER**				
		A	**B**	**C**	**D**	**E**
1	31	101	—	—	60	—
1½	45	147	—	—	90	—
2	60	200	—	—	115	—
3	87	290	—	—	180	—
5	142	475	—	—	300	—
7½	208	—	—	—	430	—
10	273	648	—	—	540	—
15	400	970	—	—	820	—
20	525	1243	—	—	1100	—
25	647	1500	—	—	1350	—
30	769	1788	—	—	1580	—
40	1007	2417	—	—	2100	—
50	1241	3036	—	—	2730	—
60	1473	3986	—	—	3240	—
75	1814	4897	—	—	3990	—
100	2372	—	—	—	5200	—
125	2919	—	—	—	6400	—
150	3456	—	—	—	7600	—
200	4508	—	—	—	10000	—
250	5540	—	—	—	—	—

Table 6. Maximum Inertial Limits (WK^2) for Three Phase Standard Design B TEFC Motors

MOTOR HP	2-POLE 3600 RPM TEFC					
	NEMA MIN. WK^2	MOTOR MANUFACTURER				
		A	B	C	D	E
1	—	9	—	—	—	—
1½	1.8	11	4.2	5	4.2	6.6
2	2.4	12	5.9	9	4.5	6.4
3	3.5	14	5.4	7	6.5	12
5	5.7	23	9.6	10	11	17
7½	8.3	30	12	8	18	19
10	11	37	14	10	26	20
15	16	65	18	47	41	38
20	21	75	27	60	53	41
25	26	100	40	89	68	77
30	31	130	49	105	83	74
40	40	151	84	125	107	80
50	49	210	114	145	150	85
60	58	270	134	145	180	119
75	71	316	188	190	240	158
100	92	420	245	295	230	193
125	113	520	—	395	280	—
150	133	—	—	565	330	—
200	172	—	—	—	430	—
250	210	—	—	—	525	—
300	246	—	—	—	615	—

MOTOR HP	4-POLE 1800 RPM TEFC					
	NEMA MIN. WK^2	MOTOR MANUFACTURER				
		A	B	C	D	E
1	5.8	23	13	27	12	37
1½	8.6	34	18	28	17	38
2	11	50	25	39	23	40
3	17	69	27	33	35	78
5	27	95	43	36	55	82
7½	39	126	55	73	80	93
10	51	145	77	90	105	107
15	75	235	93	345	220	157
20	99	340	138	475	270	178
25	122	405	186	450	340	201
30	144	465	224	500	420	223
40	189	560	312	610	540	288
50	232	710	512	765	680	338
60	275	835	666	870	800	486
75	338	1125	735	995	920	556
100	441	1720	819	1420	1190	817
125	542	2040	1047	1550	1460	—
150	640	—	1345	1970	1730	—
200	831	—	1695	2390	2240	—
250	1017	—	—	—	2740	—
300	1197	—	—	—	3230	—

MOTOR HP	6-POLE 1200 RPM TEFC					
	NEMA MIN. WK^2	MOTOR MANUFACTURER				
		A	B	C	D	E
1	15	62	27	39	24	102
1½	23	85	23	54	45	203
2	30	94	36	44	60	200
3	44	121	48	105	87	311
5	71	178	92	159	150	371
7½	104	245	98	340	240	329
10	137	368	143	420	350	350
15	200	506	241	710	530	468
20	262	800	278	895	750	550
25	324	892	356	1360	950	897
30	384	1120	565	1590	1150	646
40	503	1236	701	1420	1600	1116
50	620	1787	1168	1570	1750	1356
60	735	2489	1047	3120	1910	1564
75	904	2742	1324	3390	2350	1838
100	1181	3885	2331	4850	3070	—
125	1452	4575	2399	6430	3770	—
150	1719	—	—	6700	4290	—
200	2238	—	—	—	5590	—
250	2744	—	—	—	5200	—
300	3239	—	—	—	—	—

MOTOR HP	8-POLE 900 RPM TEFC					
	NEMA MIN. WK^2	MOTOR MANUFACTURER				
		A	B	C	D	E
1	31	121	—	—	63	—
1½	45	144	—	—	95	—
2	60	163	—	—	150	—
3	87	228	—	—	240	—
5	142	330	—	—	400	—
7½	208	480	—	—	600	—
10	273	615	—	—	730	—
15	400	900	—	—	1100	—
20	525	992	—	—	1400	—
25	647	1500	—	—	1700	—
30	769	1685	—	—	1990	—
40	1007	2554	—	—	2500	—
50	1241	2520	—	—	3000	—
60	1473	4162	—	—	4000	—
75	1814	5620	—	—	4900	—
100	2372	7661	—	—	6400	—
125	2919	9748	—	—	7900	—
150	3456	—	—	—	9400	—
200	4508	—	—	—	12400	—
250	5540	—	—	—	—	—