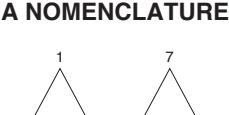
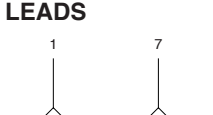
TERMINAL MARKINGS AND CONNECTIONS
PART WINDING START

NEMA NOMENCLATURE—6 LEADS

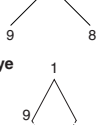


Delta



Wye

OPER. MODE	L1	L2	L3	OPEN
START	1	2	3	7,8,9
RUN	1,7	2,8	3,9	—



Double Delta
(Extended Delta)

NEMA NOMENCLATURE—9 LEADS

WYE CONNECTED (LOW VOLTAGE ONLY)

	T1	T2	T3	T7	T8	T9	Together
MOTOR LEADS	1	2	3	7	8	9	4&5&6

NEMA AND IEC NOMENCLATURE—12 LEADS

SINGLE VOLTAGE OR LOW VOLTAGE OF DUAL-VOLTAGE MOTORS

	T1	T2	T3	T7	T8	T9
NEMA	1,6	2,4	3,5	7,12	8,10	9,11
IEC	U1,W2	V1,U2	W1,V2	U5,W6	V5,U6	W5,V6

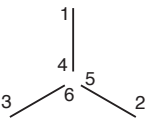
TERMINAL MARKINGS AND CONNECTIONS

THREE-PHASE MOTORS–SINGLE SPEED

NEMA NOMENCLATURE—6 LEADS

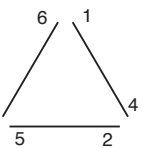
SINGLE VOLTAGE
EXTERNAL WYE CONNECTION

L1	L2	L3	JOIN
1	2	3	4&5&6

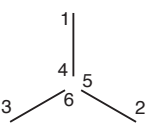


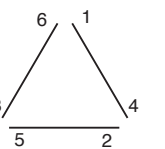
SINGLE VOLTAGE
EXTERNAL DELTA CONNECTION

L1	L2	L3
1,6	2,4	3,5



SINGLE AND DUAL VOLTAGE
WYE-DELTA CONNECTIONS





SINGLE VOLTAGE

OPERATING MODE	CONNECTION	L1	L2	L3	JOIN
START	WYE	1	2	3	4&5&6
RUN	DELTA	1,6	2,4	3,5	—

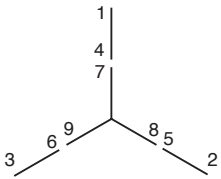
DUAL VOLTAGE*

VOLTAGE	CONNECTION	L1	L2	L3	JOIN
HIGH	WYE	1	2	3	4&5&6
LOW	DELTA	1,6	2,4	3,5	—

*Voltage ratio: 1.732 to 1.

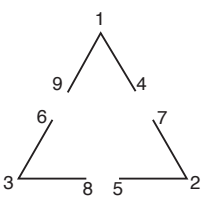
TERMINAL MARKINGS AND CONNECTIONS
THREE-PHASE MOTORS–SINGLE SPEED

NEMA NOMENCLATURE—9 LEADS



DUAL VOLTAGE
WYE-CONNECTED

VOLTAGE	L1	L2	L3	JOIN
HIGH	1	2	3	4&7,5&8,6&9
LOW	1,7	2,8	3,9	4&5&6

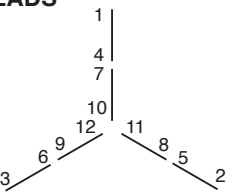


DUAL VOLTAGE
DELTA-CONNECTED

VOLTAGE	L1	L2	L3	JOIN
HIGH	1	2	3	4&7,5&8,6&9
LOW	1,6,7	2,4,8	3,5,9	—

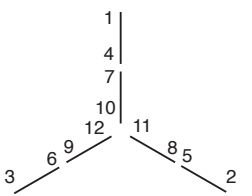
TERMINAL MARKINGS AND CONNECTIONS
THREE-PHASE MOTORS–SINGLE SPEED

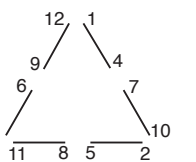
NEMA NOMENCLATURE–12 LEADS



DUAL VOLTAGE
EXTERNAL WYE CONNECTION

VOLTAGE	L1	L2	L3	JOIN
HIGH	1	2	3	4&7,5&8,6&9, 10&11&12
LOW	1,7	2,8	3,9	4&5&6, 10&11&12





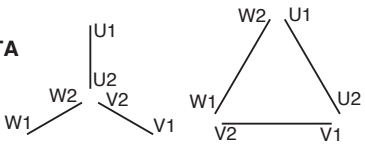
DUAL VOLTAGE
WYE-CONNECTED START
DELTA-CONNECTED RUN

VOLTAGE	CONN.	L1	L2	L3	JOIN
HIGH	WYE	1	2	3	4&7,5&8,6&9, 10&11&12
	DELTA	1,12	2,10	3,11	4&7,5&8,6&9
LOW	WYE	1,7	2,8	3,9	4&5&6, 10&11&12
	DELTA	1,6,7, 12	2,4,8, 10	3,5,9, 11	—

TERMINAL MARKINGS AND CONNECTIONS
THREE-PHASE MOTORS–SINGLE SPEED

IEC NOMENCLATURE–6 AND 12 LEADS

SINGLE AND DUAL VOLTAGE WYE-DELTA CONNECTIONS



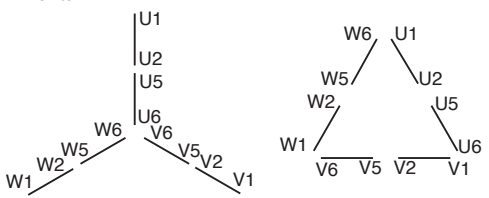
SINGLE VOLTAGE

OPER. MODE	CONN.	L1	L2	L3	JOIN
START	WYE	U1	V1	W1	U2&V2&W2
RUN	DELTA	U1,W2	V1,U2	W1,V2	—

DUAL VOLTAGE*

VOLT.	CONN.	L1	L2	L3	JOIN
HIGH	WYE	U1	V1	W1	U2&V2&W2
LOW	DELTA	U1,W2	V1,U2	W1,V2	—

*Voltage ratio: 1.732 to 1.



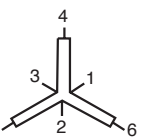
DUAL VOLTAGE WYE-CONNECTED START DELTA-CONNECTED RUN

VOLT.	CONN.	L1	L2	L3	JOIN
HIGH	WYE	U1	V1	W1	U2&U5,V2&V5, W2&W5,U6&V6&W6
	DELTA	U1,W6	V1,U6	W1,V6	U2&U5,V2&V5, W2&W5
LOW	WYE	U1,U5	V1,V5	W1,W5	U2&V2&W2, U6&V6&W6
	DELTA	U1,U5, W2,W6	V1,V5, U2,U6	W1,W5, V2,V6	—

TERMINAL MARKINGS AND CONNECTIONS

THREE-PHASE MOTORS–TWO SPEED, SINGLE WINDING

NEMA NOMENCLATURE–6 LEADS



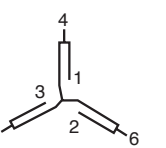
CONSTANT TORQUE CONNECTION

Low-speed horsepower is half of high-speed horsepower.*

SPEED	L1	L2	L3		TYPICAL CONNECTION
HIGH	6	4	5	1&2&3 JOIN	2 WYE
LOW	1	2	3	4-5-6 OPEN	1 DELTA

VARIABLE TORQUE CONNECTION

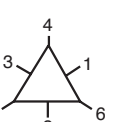
Low-speed horsepower is one-fourth of high-speed horsepower.*



SPEED	L1	L2	L3		TYPICAL CONNECTION
HIGH	6	4	5	1&2&3 JOIN	2 WYE
LOW	1	2	3	4-5-6 OPEN	1 WYE

CONSTANT HORSEPOWER CONNECTION

Horsepower is the same at both speeds.



SPEED	L1	L2	L3		TYPICAL CONNECTION
HIGH	6	4	5	1-2-3 OPEN	1 DELTA
LOW	1	2	3	4&5&6 JOIN	2 WYE

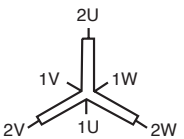
* CAUTION: On European motors horsepower variance with speed may not be the same as shown above.

TERMINAL MARKINGS AND CONNECTIONS

THREE-PHASE MOTORS–TWO SPEED,
SINGLE WINDING

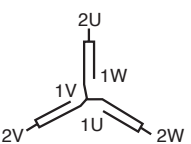
IEC NOMENCLATURE–6 LEADS

CONSTANT TORQUE CONNECTION



SPEED	L1	L2	L3		TYPICAL CONN.
HIGH	2W	2U	2V	1U&1V&1W JOIN	2 WYE
LOW	1U	1V	1W	2U-2V-2W OPEN	1 DELTA

VARIABLE TORQUE CONNECTION



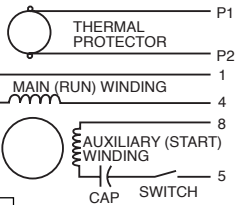
SPEED	L1	L2	L3		TYPICAL CONN.
HIGH	2W	2U	2V	1U&1V&1W JOIN	2 WYE
LOW	1U	1V	1W	2U-2V-2W OPEN	1 WYE

TERMINAL MARKINGS AND CONNECTIONS

SINGLE-PHASE MOTORS–CAPACITOR-START

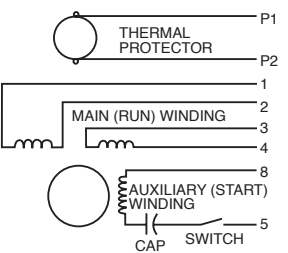
NEMA NOMENCLATURE

SINGLE VOLTAGE



ROTATION	L1	L2
CCW	1,8	4,5
CW	1,5	4,8

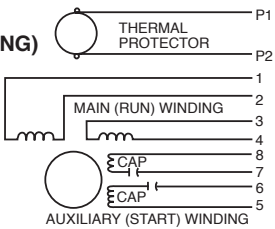
DUAL VOLTAGE (MAIN WINDING ONLY)
Auxiliary winding is always at low voltage rating; capacitor should be rated accordingly.



VOLTAGE	ROTATION	L1	L2	JOIN
HIGH	CCW	1	4,5	2&3&8
	CW	1	4,8	2&3&5
LOW	CCW	1,3,8	2,4,5	—
	CW	1,3,5	2,4,8	—

NEMA NOMENCLATURE

DUAL VOLTAGE
(MAIN AND AUXILIARY WINDING)
Capacitors in auxiliary windings are rated for lower voltage.



VOLTAGE	ROTATION	L1	L2	JOIN
HIGH	CCW	1,8	4,5	2&3,6&7
	CW	1,5	4,8	2&3,6&7
LOW	CCW	1,3,6,8	2,4,5,7	—
	CW	1,3,5,7	2,4,6,8	—

The switch in the auxiliary winding circuit has been omitted from this diagram. The connections to the switch must be made so that *both* auxiliary windings become de-energized when the switch is open.

ROTATION: CCW – Counter-clockwise
CW – Clockwise

The direction of shaft rotation can be determined by facing the end of the motor opposite the drive.

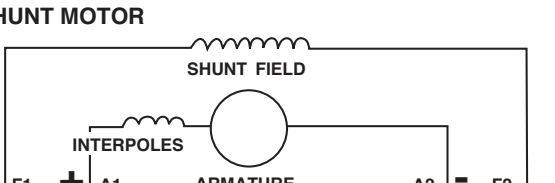
TERMINAL MARKINGS IDENTIFIED BY COLOR

1-Blue	5-Black	P1-No color assigned
2-White	6-No color assigned	P2-Brown
3-Orange	7-No color assigned	
4-Yellow	8-Red	

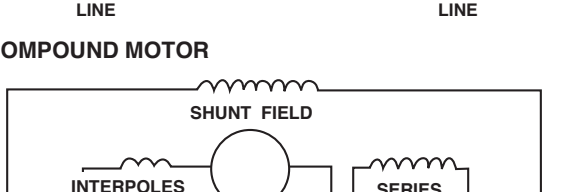
NEMA MG 1-1998 (Rev. 3), 2.41. Note: May not apply for some definite-purpose motors.

TERMINAL MARKINGS AND CONNECTIONS
FOR DC MOTORS (NEMA NOMENCLATURE)

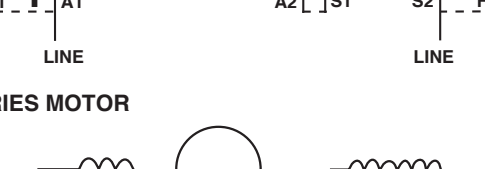
SHUNT MOTOR



COMPOUND MOTOR



SERIES MOTOR



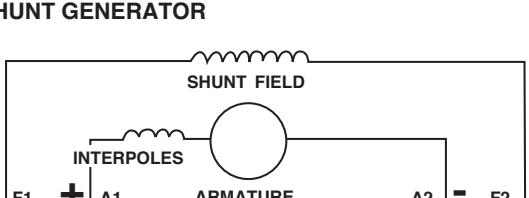
All connections are for counterclockwise rotation facing the end opposite the drive. For clockwise rotation, interchange A1 and A2.

Some manufacturers connect the interpole winding on the A2 side of the armature.

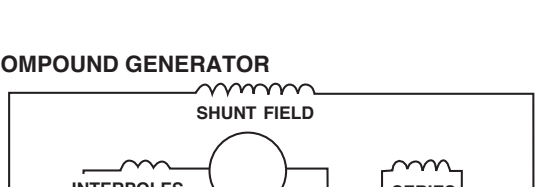
When the shunt field is separately excited, the same polarities must be observed for a given rotation.

TERMINAL MARKINGS AND CONNECTIONS
FOR DC GENERATORS (NEMA NOMENCLATURE)

SHUNT GENERATOR



COMPOUND GENERATOR



All connections are for counterclockwise rotation facing the end opposite the drive. For clockwise rotation, interchange A1 and A2.

Some manufacturers connect the interpole winding on the A2 side of the armature.

For the above generators, the shunt field may be either self-excited or separately excited. When it is self-excited, connections should be made as shown by the dotted lines. When the shunt field is separately excited, it is usually isolated from the other windings of the machine, but the polarity or the voltage applied to the shunt field should be as shown for the particular rotation and armature polarity.

NEMA MG 1-1998 (Rev. 3), 2.14, Note 5.

FULL-LOAD CURRENTS OF DC MOTORS*
(RUNNING AT BASE SPEED)

*For conductor slzlng only.

FULL-LOAD CURRENT IN AMPERES†

	RATED ARMATURE VOLTAGE					
HP	**90V**	**120V**	**180V**	**240V**	**500V**	**550V**
.25	4.0	3.1	2.0	1.6	—	—
.33	5.2	4.1	2.6	2.0	—	—
.5	6.8	5.4	3.4	2.7	—	—
.75	9.6	7.6	4.8	3.8	—	—
1	12.2	9.5	6.1	4.7	—	—
1.5	—	13.2	8.3	6.6	—	—
2	—	17	10.8	8.5	—	—
3	—	25	16	12.2	—	—
5	—	40	27	20	—	—
7.5	—	58	—	29	13.6	12.2
10	—	76	—	38	18	16
15	—	—	—	55	27	24
20	—	—	—	72	34	31
25	—	—	—	89	43	38
30	—	—	—	106	51	46
40	—	—	—	140	67	61
50	—	—	—	173	83	75
60	—	—	—	206	99	90
75	—	—	—	255	123	111
100	—	—	—	341	164	148
125	—	—	—	425	205	185
150	—	—	—	506	246	222
200	—	—	—	675	330	294
OVER 200 HP						
Approx. Amps/hp	—	—	—	3.4	1.7	1.5

†These are average direct-current quantities.

Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating.

Armature current varies inversely as applied voltage.

Example: 40 hp motor, 300 volt armature

$$\text{Armature current} = 140 \times \frac{240}{300} = 112 \text{ amps}$$

The above table is based on Table 430.147 of the *National Electrical Code®*, 2002. *National Electrical Code®* and NEC® are registered trade marks of the National Fire Protection Association, Inc. Quincy, MA 02269.

FULL-LOAD CURRENTS

THREE-PHASE SQUIRREL CAGE
AND WOUND-ROTOR MOTORS*

*For conductor sizing only

FULL-LOAD CURRENT IN AMPERES

HP	200V	208V	230V	460V	575V	2300V	4000V
.5	2.5	2.4	2.2	1.1	0.9	—	—
.75	3.7	3.5	3.2	1.6	1.3	—	—
1	4.8	4.6	4.2	2.1	1.7	—	—
1.5	6.9	6.6	6.0	3.0	2.4	—	—
2	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	—	—
7.5	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	—	—
30	92	88	80	40	32	—	—
40	120	114	104	52	41	—	—
50	150	143	130	65	52	—	—
60	177	169	154	77	62	16	9
75	221	211	192	96	77	20	11
100	285	273	248	124	99	26	14
125	359	343	312	156	125	31	18
150	414	396	360	180	144	37	21
200	552	528	480	240	192	49	28
250	—	—	—	302	242	60	35
300	—	—	—	361	289	72	41
350	—	—	—	414	336	83	48
400	—	—	—	477	382	95	55
450	—	—	—	515	412	103	59
500	—	—	—	590	472	118	68
OVER 200 HP							
Approx. Amps/hp	2.75	2.64	2.4	1.2	.96	.24	.14

Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating. Based on Table 430.150 of the *National Electrical Code*,® 2002.

FULL-LOAD CURRENTS

THREE-PHASE SYNCHRONOUS MOTORS (UNITY POWER FACTOR) AND SINGLE-PHASE MOTORS*

*For conductor sizing only

THREE-PHASE SYNCHRONOUS MOTORS

FULL-LOAD CURRENT IN AMPERES

	RATED VOLTAGE			
HP	**460V**	**575V**	**2300V**	**4000V**
100	100	80	20	12
125	125	100	25	14
150	150	120	30	17
200	200	160	40	23
250	250	200	50	29
300	300	240	60	35
350	353	282	71	41
400	403	322	80	46
500	500	400	100	58
600	600	480	120	69
700	705	564	141	81
800	805	644	161	93
900	905	724	181	104
1000	960	768	192	110

SINGLE-PHASE MOTORS

FULL-LOAD CURRENT IN AMPERES

	RATED VOLTAGE			
HP	**115V**	**200V**	**208V**	**230V**
.167	4.4	2.5	2.4	2.2
.25	5.8	3.3	3.2	2.9
.34	7.2	4.1	4.0	3.6
.5	9.8	5.6	5.4	4.9
.75	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8
1.5	20	11.5	11	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7.5	80	46	44	40
10	100	57.5	55	50

Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating.

Based on Table 430.148 of the *National Electrical Code®*, 2002.

MAXIMUM LOCKED-ROTOR CURRENTS

THREE-PHASE SQUIRREL CAGE MOTORS
NEMA DESIGNS B, C AND D

LOCKED-ROTOR CURRENT IN AMPERES

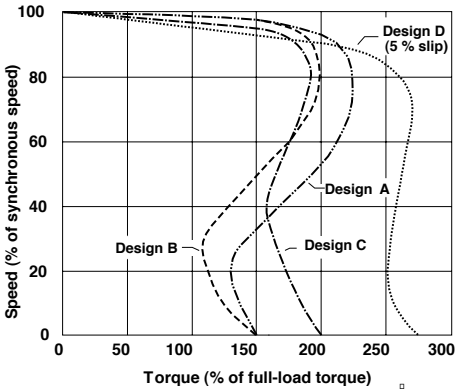
	RATED VOLTAGE, 60 Hz					
HP	**200V**	**230V**	**460V**	**575V**	**2300V**	**4000V**
.5	23	20	10	8		
.75	29	25	12	10		
1	34	30	15	12		
1.5	46	40	20	16		
2	57	50	25	20		
3	74	64	32	26		
5	106	92	46	37		
7.5	146	127	63	51		
10	186	162	81	65		
15	267	232	116	93		
20	333	290	145	116		
25	420	365	182	146		
30	500	435	217	174		
40	667	580	290	232		
50	834	725	362	290		
60	1000	870	435	348	87	50
75	1250	1085	542	434	108	62
100	1665	1450	725	580	145	83
125	2085	1815	907	726	181	104
150	2500	2170	1085	868	217	125
200	3335	2900	1450	1160	290	167
250	4200	3650	1825	1460	365	210
300	5060	4400	2200	1760	440	253
350	5860	5100	2550	2040	510	293
400	6670	5800	2900	2320	580	333
450	7470	6500	3250	2600	650	374
500	8340	7250	3625	2900	725	417

The locked-rotor current of Design B, C and D constant-speed induction motors, when measured with rated voltage and frequency impressed and with rotor locked, shall not exceed the above values.

Reference: NEMA MG 1-1998 (Rev. 3), 12.35.1. See NEMA MG 1-1998 (Rev. 3), 12.35.3 for 50 Hz, 380 volts.

GENERAL SPEED-TORQUE CHARACTERISTICS

THREE-PHASE INDUCTION MOTORS



NEMA DESIGN	LOCKED ROTOR TORQUE	BREAKDOWN TORQUE	LOCKED ROTOR CURRENT	SLIP	RELATIVE EFFICIENCY
B	70 - 275%*	175 - 300%*	600 - 800%	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 - 800%	1-5%	Medium
	Applications: Conveyors, crushers, stirring machines, agitators, reciprocating pumps and compressors, etc., where starting under load is required.				
D	275%	275%	600 - 800%	≥5%	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 MG 10-2001, Table 1. NEMA Design A is a variation of Design B having higher locked-rotor current.

*Higher values are for motors having lower horsepower ratings.

FULL-LOAD EFFICIENCIES

THREE-PHASE, SQUIRREL CAGE, ENERGY EFFICIENT OPEN MOTORS (NEMA DESIGNS A AND B)

HP	2 POLE		4 POLE		6 POLE	
	NOMINAL EFFICIENCY	MINIMUM EFFICIENCY	NOMINAL EFFICIENCY	MINIMUM EFFICIENCY	NOMINAL EFFICIENCY	MINIMUM EFFICIENCY
1.0			82.5	80.0	80.0	77.0
1.5	82.5	80.0	84.0	81.5	84.0	81.5
2.0	84.0	81.5	84.0	81.5	85.5	82.5
3.0	84.0	81.5	86.5	84.0	86.5	84.0
5.0	85.5	82.5	87.5	85.5	87.5	85.5
7.5	87.5	85.5	88.5	86.5	88.5	86.5
10.0	88.5	86.5	89.5	87.5	90.2	88.5
15.0	89.5	87.5	91.0	89.5	90.2	88.5
20.0	90.2	88.5	91.0	89.5	91.0	89.5
25.0	91.0	89.5	91.7	90.2	91.7	90.2
30.0	91.0	89.5	92.4	91.0	92.4	91.0
40.0	91.7	90.2	93.0	91.7	93.0	91.7
50.0	92.4	91.0	93.0	91.7	93.0	91.7
60.0	93.0	91.7	93.6	92.4	93.6	92.4
75.0	93.0	91.7	94.1	93.0	93.6	92.4
100.0	93.0	91.7	94.1	93.0	94.1	93.0
125.0	93.6	92.4	94.5	93.6	94.1	93.0
150.0	93.6	92.4	95.0	94.1	94.5	93.6
200.0	94.5	93.6	95.0	94.1	94.5	93.6
250.0	94.5	93.6	95.4	94.5	95.4	94.5
300.0	95.0	94.1	95.4	94.5	95.4	94.5
350.0	95.0	94.1	95.4	94.5	95.4	94.5
400.0	95.4	94.5	95.4	94.5		
450.0	95.8	95.0	95.8	95.0		
500.0	95.8	95.0	95.8	95.0		

The full load efficiency of Design A and B motors rated 600 volts or less, when operating at rated voltage and frequency, shall not be less than the minimum efficiency listed in the table above for the motor to be classified as “energy efficient.” Nominal efficiency represents a value which should be used to compute the energy consumption of a motor or group of motors.

Reference: NEMA MG 1-1998 (Rev. 3), 12.60, Table 12-11.

The Energy Policy Act of 1992 (USA): The nominal full-load efficiency of electric motors as specified in the Energy Policy Act of 1992 is the same as that listed in the table for 1.0 to 200.0 hp motors.

FULL-LOAD EFFICIENCIES

THREE-PHASE, SQUIRREL CAGE, ENERGY EFFICIENT ENCLOSED MOTORS (NEMA DESIGNS A AND B)

HP	2 POLE		4 POLE		6 POLE	
	NOMINAL EFFICIENCY	MINIMUM EFFICIENCY	NOMINAL EFFICIENCY	MINIMUM EFFICIENCY	NOMINAL EFFICIENCY	MINIMUM EFFICIENCY
1.0	75.5	72.0	82.5	80.0	80.0	77.0
1.5	82.5	80.0	84.0	81.5	85.5	82.5
2.0	84.0	81.5	84.0	81.5	86.5	84.0
3.0	85.5	82.5	87.5	85.5	87.5	85.5
5.0	87.5	85.5	87.5	85.5	87.5	85.5
7.5	88.5	86.5	89.5	87.5	89.5	87.5
10.0	89.5	87.5	89.5	87.5	89.5	87.5
15.0	90.2	88.5	91.0	89.5	90.2	88.5
20.0	90.2	88.5	91.0	89.5	90.2	88.5
25.0	91.0	89.5	92.4	91.0	91.7	90.2
30.0	91.0	89.5	92.4	91.0	91.7	90.2
40.0	91.7	90.2	93.0	91.7	93.0	91.7
50.0	92.4	91.0	93.0	91.7	93.0	91.7
60.0	93.0	91.7	93.6	92.4	93.6	92.4
75.0	93.0	91.7	94.1	93.0	93.6	92.4
100.0	93.6	92.4	94.5	93.6	94.1	93.0
125.0	94.5	93.6	94.5	93.6	94.1	93.0
150.0	94.5	93.6	95.0	94.1	95.0	94.1
200.0	95.0	94.1	95.0	94.1	95.0	94.1
250.0	95.4	94.5	95.0	94.1	95.0	94.1
300.0	95.4	94.5	95.4	94.5	95.0	94.1
350.0	95.4	94.5	95.4	94.5	95.0	94.1
400.0	95.4	94.5	95.4	94.5		
450.0	95.4	94.5	95.4	94.5		
500.0	95.4	94.5	95.8	95.0		

The full load efficiency of Design A and B motors rated 600 volts or less, when operating at rated voltage and frequency, shall not be less than the minimum efficiency listed in the table above for the motor to be classified as “energy efficient.” Nominal efficiency represents a value which should be used to compute the energy consumption of a motor or group of motors.

Reference: NEMA MG 1-1998 (Rev. 3), 12.60, Table 12-11.

The Energy Policy Act of 1992 (USA): The nominal full-load efficiency of electric motors as specified in the Energy Policy Act of 1992 is the same as that listed in the table for 1.0 to 200.0 hp motors.

NEMA FRAME ASSIGNMENTS

THREE-PHASE OPEN MOTORS—GENERAL PURPOSE

NEMA PROGRAM HP	3600 RPM			1800 RPM			1200 RPM			900 RPM		
	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-belts or chain drive, the correct frame size is the one shown but with the suffix letter S omitted. For the corresponding shaft extension dimensions, see Pages 28-31.

NEMA FRAME ASSIGNMENTS

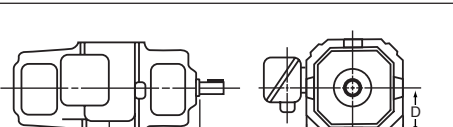
THREE-PHASE TEFC MOTORS—GENERAL PURPOSE

NEMA PROGRAM HP	3600 RPM			1800 RPM			1200 RPM			900 RPM		
	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 frame size shown but with the suffix letter S omitted. For the corresponding shaft extension dimensions, see Pages 28-31.

NEMA FRAME DIMENSIONS*
FOOT-MOUNTED DC MACHINES



*** Dimensions in inches**

FRAME	A MAX	B MAX	D	E	2F	BA	H
42			2.62	1.75	1.69	2.06	0.28
48			3.00	2.12	2.75	2.50	0.34
56			3.50	2.44	3.00	2.75	0.34
56H			3.50	2.44	5.00	2.75	0.34
142AT	7.00	6.75	3.50	2.75	3.50	2.75	0.34
143AT	7.00	7.25	3.50	2.75	4.00	2.75	0.34
144AT	7.00	7.75	3.50	2.75	4.50	2.75	0.34
145AT	7.00	8.25	3.50	2.75	5.00	2.75	0.34
146AT	7.00	8.75	3.50	2.75	5.50	2.75	0.34
147AT	7.00	9.50	3.50	2.75	6.25	2.75	0.34
148AT	7.00	10.25	3.50	2.75	7.00	2.75	0.34
149AT	7.00	11.25	3.50	2.75	8.00	2.75	0.34
1410AT	7.00	12.25	3.50	2.75	9.00	2.75	0.34
1411AT	7.00	13.25	3.50	2.75	10.00	2.75	0.34
1412AT	7.00	14.25	3.50	2.75	11.00	2.75	0.34
162AT	8.00	6.00	4.00	3.12	4.00	2.50	0.41
163AT	8.00	6.50	4.00	3.12	4.50	2.50	0.41
164AT	8.00	7.00	4.00	3.12	5.00	2.50	0.41
165AT	8.00	7.50	4.00	3.12	5.50	2.50	0.41
166AT	8.00	8.20	4.00	3.12	6.25	2.50	0.41
167AT	8.00	9.00	4.00	3.12	7.00	2.50	0.41
168AT	8.00	10.00	4.00	3.12	8.00	2.50	0.41
169AT	8.00	11.00	4.00	3.12	9.00	2.50	0.41
1610AT	8.00	12.00	4.00	3.12	10.00	2.50	0.41
182AT	9.00	6.50	4.50	3.75	4.50	2.75	0.41
183AT	9.00	7.00	4.50	3.75	5.00	2.75	0.41
184AT	9.00	7.50	4.50	3.75	5.50	2.75	0.41
185AT	9.00	8.25	4.50	3.75	6.25	2.75	0.41
186AT	9.00	9.00	4.50	3.75	7.00	2.75	0.41
187AT	9.00	10.00	4.50	3.75	8.00	2.75	0.41
188AT	9.00	11.00	4.50	3.75	9.00	2.75	0.41
189AT	9.00	12.00	4.50	3.75	10.00	2.75	0.41
1810AT	9.00	13.00	4.50	3.75	11.00	2.75	0.41
213AT	10.50	7.50	5.25	4.25	5.50	3.50	0.41
214AT	10.50	8.25	5.25	4.25	6.25	3.50	0.41
215AT	10.50	9.00	5.25	4.25	7.00	3.50	0.41
216AT	10.50	10.00	5.25	4.25	8.00	3.50	0.41
217AT	10.50	11.00	5.25	4.25	9.00	3.50	0.41
218AT	10.50	12.00	5.25	4.25	10.00	3.50	0.41
219AT	10.50	13.00	5.25	4.25	11.00	3.50	0.41
2110AT	10.50	14.50	5.25	4.25	12.50	3.50	0.41
253AT	12.50	9.50	6.25	5.00	7.00	4.25	0.53
254AT	12.50	10.75	6.25	5.00	8.25	4.25	0.53
255AT	12.50	11.50	6.25	5.00	9.00	4.25	0.53
256AT	12.50	12.50	6.25	5.00	10.00	4.25	0.53
257AT	12.50	13.50	6.25	5.00	11.00	4.25	0.53
258AT	12.50	15.00	6.25	5.00	12.50	4.25	0.53
259AT	12.50	16.50	6.25	5.00	14.00	4.25	0.53

NEMA FRAME DIMENSIONS*
FOOT-MOUNTED DC MACHINES–CONTINUED

*** Dimensions in inches**

FRAME	A MAX	B MAX	D	E	2F	BA	H†
283AT	14.00	11.00	7.00	5.50	8.00	4.75	0.53
284AT	14.00	12.50	7.00	5.50	9.50	4.75	0.53
285AT	14.00	13.00	7.00	5.50	10.00	4.75	0.53
286AT	14.00	14.00	7.00	5.50	11.00	4.75	0.53
287AT	14.00	15.50	7.00	5.50	12.50	4.75	0.53
288AT	14.00	17.00	7.00	5.50	14.00	4.75	0.53
289AT	14.00	19.00	7.00	5.50	16.00	4.75	0.53
323AT	16.00	12.50	8.00	6.25	9.00	5.25	0.66
324AT	16.00	14.00	8.00	6.25	10.50	5.25	0.66
325AT	16.00	14.50	8.00	6.25	11.00	5.25	0.66
326AT	16.00	15.50	8.00	6.25	12.00	5.25	0.66
327AT	16.00	17.50	8.00	6.25	14.00	5.25	0.66
328AT	16.00	19.50	8.00	6.25	16.00	5.25	0.66
329AT	16.00	21.50	8.00	6.25	18.00	5.25	0.66
363AT	18.00	14.00	9.00	7.00	10.00	5.88	0.81
364AT	18.00	15.25	9.00	7.00	11.25	5.88	0.81
365AT	18.00	16.25	9.00	7.00	12.25	5.88	0.81
366AT	18.00	18.00	9.00	7.00	14.00	5.88	0.81
367AT	18.00	20.00	9.00	7.00	16.00	5.88	0.81
368AT	18.00	22.00	9.00	7.00	18.00	5.88	0.81
369AT	18.00	24.00	9.00	7.00	20.00	5.88	0.81
403AT	20.00	15.00	10.00	8.00	11.00	6.62	0.94
404AT	20.00	16.25	10.00	8.00	12.25	6.62	0.94
405AT	20.00	17.75	10.00	8.00	13.75	6.62	0.94
406AT	20.00	20.00	10.00	8.00	16.00	6.62	0.94
407AT	20.00	22.00	10.00	8.00	18.00	6.62	0.94
408AT	20.00	24.00	10.00	8.00	20.00	6.62	0.94
409AT	20.00	26.00	10.00	8.00	22.00	6.62	0.94
443AT	22.00	16.50	11.00	9.00	12.50	7.50	1.06
444AT	22.00	18.50	11.00	9.00	15.00	7.50	1.06
445AT	22.00	20.50	11.00	9.00	16.50	7.50	1.06
446AT	22.00	22.00	11.00	9.00	18.00	7.50	1.06
447AT	22.00	24.00	11.00	9.00	20.00	7.50	1.06
448AT	22.00	26.00	11.00	9.00	22.00	7.50	1.06
449AT	22.00	29.00	11.00	9.00	25.00	7.50	1.06
502AT	25.00	17.50	12.50	10.00	12.50	8.50	1.19
503AT	25.00	19.00	12.50	10.00	14.00	8.50	1.19
504AT	25.00	21.00	12.50	10.00	16.00	8.50	1.19
505AT	25.00	23.00	12.50	10.00	18.00	8.50	1.19
506AT	25.00	25.00	12.50	10.00	20.00	8.50	1.19
507AT	25.00	27.00	12.50	10.00	22.00	8.50	1.19
508AT	25.00	30.00	12.50	10.00	25.00	8.50	1.19
509AT	25.00	33.00	12.50	10.00	28.00	8.50	1.19
583A	29.00	21.00	14.50	11.50	16.00	10.00	1.19
584A	29.00	23.00	14.50	11.50	18.00	10.00	1.19
585A	29.00	25.00	14.50	11.50	20.00	10.00	1.19
586A	29.00	27.00	14.50	11.50	22.00	10.00	1.19
587A	29.00	30.00	14.50	11.50	25.00	10.00	1.19
588A	29.00	33.00	14.50	11.50	28.00	10.00	1.19
683A	34.00	25.00	17.00	13.50	20.00	11.50	1.19
684A	34.00	27.00	17.00	13.50	22.00	11.50	1.19
685A	34.00	30.00	17.00	13.50	25.00	11.50	1.19
686A	34.00	33.00	17.00	13.50	28.00	11.50	1.19
687A	34.00	37.00	17.00	13.50	32.00	11.50	1.19
688A	34.00	41.00	17.00	13.50	36.00	11.50	1.19

References and tolerances on dimensions: NEMA MG 1-1998 (Rev. 3), 4.5.1, 4.5.2, 4.5.3 and 4.9.

† Frames 42 to 56H, inclusive—The H dimension is *Width of Slot*. Frames 142AT to 688A, inclusive—The H dimension is *Diameter of Hole*.

NEMA SIZE STARTERS
FOR THREE-PHASE MOTORS

NEMA SIZE	MAXIMUM HORSEPOWER—THREE-PHASE MOTORS											
	FULL VOLTAGE STARTING			AUTOTRANSFORMER STARTING			PART-WINDING STARTING			WYE-DELTA STARTING		
	200V	230V	460V 575V	200V	230V	460V 575V	200V	230V	460V 575V	200V	230V	460V 575V
00	1.5	1.5	2	—	—	—	—	—	—	—	—	—
0	3	3	5	—	—	—	—	—	—	—	—	—
1	7.5	7.5	10	7.5	7.5	10	10	10	15	10	10	15
2	10	15	25	10	15	25	20	25	40	20	25	40
3	25	30	50	25	30	50	40	50	75	40	50	75
4	40	50	100	40	50	100	75	75	150	60	75	150
5	75	100	200	75	100	200	150	150	350	150	150	300
6	150	200	400	150	200	400	—	300	600	300	350	700
7	—	300	600	—	300	600	—	450	900	500	500	1000
8	—	450	900	—	450	900	—	700	1400	750	800	1500
9	—	800	1600	—	800	1600	—	1300	2600	1500	1500	3000

STARTER ENCLOSURES

TYPE	NEMA ENCLOSURE
1	General Purpose—Indoor
2	Dripproof—Indoor
3	Dusttight, Raintight, Sleettight—Outdoor
3R	Raintight, Sleet Resistant—Outdoor
3S	Dusttight, Raintight, Sleettight—Outdoor
4	Watertight, Dusttight, Sleet Resistant—Indoor & Outdoor
4X	Watertight, Dusttight, Corrosion-Resistant—Indoor & Outdoor
5	Dusttight, Dripproof—Indoor
6	Occasionally Submersible, Watertight, Sleet Resistant—Indoor & Outdoor
6P	Watertight, Sleet Resistant—Prolonged Submersion—Indoor & Outdoor
12	Dusttight and Driptight—Indoor
12K	Dusttight and Driptight, with Knockouts—Indoor
13	Oiltight and Dusttight—Indoor
	HAZARDOUS LOCATION STARTERS
7	Class I, Group A, B, C or D Hazardous Locations—Indoor
8	Class I, Group A, B, C or D Hazardous Locations—Indoor & Outdoor
9	Class II, Group E, F or G Hazardous Locations—Indoor
10	Requirements of Mine Safety and Health Administration

CONVERSION OF NEMA TYPE NUMBERS TO IEC CLASSIFICATION DESIGNATIONS

(Cannot be used to convert IEC Classification Designations to NEMA Type Numbers)

NEMA ENCLOSURE TYPE NUMBER	IEC ENCLOSURE CLASSIFICATION DESIGNATION
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

Note: This comparison is based on tests specified in IEC Publication 60529 (2001-02).
Reference: Information in the above tables is based on NEMA 250-1997.

NEMA SIZE STARTERS
FOR SINGLE-PHASE MOTORS

SIZE OF CONTROLLER	CONTINUOUS CURRENT RATING (AMPERES)	HORSEPOWER	
		AT 115V	AT 230V
00	9	1/3	1
0	18	1	2
1	27	2	3
1P	36	3	5
2	45	3	7 1/2
3	90	7 1/2	15

Reference: NEMA ICS2-1993, Table 2-4-2.

DERATING FACTORS FOR CONDUCTORS IN A CONDUIT (PAGES 70 - 72)

NUMBER OF CURRENT CARRYING CONDUCTORS	PERCENT OF VALUES IN TABLES AS ADJUSTED FOR TEMPERATURE IF NECESSARY
4-6	80
7-9	70
10-20	50
21-30	45
31-40	40
41 & Above	35

COMMON FRACTIONS OF AN INCH

DECIMAL AND METRIC EQUIVALENTS

FRACTION	DECIMAL	mm	FRACTION	DECIMAL	mm
1/64	0.01562	0.397	33/64	0.51562	13.097
1/32	0.03125	0.794	17/32	0.53125	13.494
3/64	0.04688	1.191	35/64	0.54688	13.891
1/16	0.06250	1.588	9/16	0.56250	14.288
5/64	0.07812	1.984	37/64	0.57812	14.684
3/32	0.09375	2.381	19/32	0.59375	15.081
7/64	0.10938	2.778	39/64	0.60938	15.478
1/8	0.12500	3.175	5/8	0.62500	15.875
9/64	0.14062	3.572	41/64	0.64062	16.272
5/32	0.15625	3.969	21/32	0.65625	16.669
11/64	0.17188	4.366	43/64	0.67188	17.066
3/16	0.18750	4.763	11/16	0.68750	17.463
13/64	0.20312	5.159	45/64	0.70312	17.859
7/32	0.21875	5.556	23/32	0.71875	18.256
15/64	0.23438	5.953	47/64	0.73438	18.653
1/4	0.25000	6.350	3/4	0.75000	19.05
17/64	0.26562	6.747	49/64	0.76562	19.447
9/32	0.28125	7.144	25/32	0.78125	19.844
19/64	0.29688	7.541	51/64	0.79688	20.241
5/16	0.31250	7.938	13/16	0.81250	20.638
21/64	0.32812	8.334	53/64	0.82812	21.034
11/32	0.34375	8.731	27/32	0.84375	21.431
23/64	0.35938	9.128	55/64	0.85938	21.828
3/8	0.37500	9.525	7/8	0.87500	22.225
25/64	0.39062	9.922	57/64	0.89062	22.622
13/32	0.40625	10.319	29/32	0.90625	23.019
27/64	0.42188	10.716	59/64	0.92188	23.416
7/16	0.43750	11.113	15/16	0.93750	23.813
29/64	0.45312	11.509	61/64	0.95312	24.209
15/32	0.46875	11.906	31/32	0.96875	24.606
31/64	0.48438	12.303	63/64	0.98438	25.003
1/2	0.50000	12.700	1/1	1.00000	25.400

USEFUL FORMULAS

FORMULAS FOR ELECTRIC MOTORS

TO FIND	DIRECT CURRENT	SINGLE PHASE	THREE PHASE
Horsepower	$\frac{E \times I \times EFF}{746}$	$\frac{E \times I \times EFF \times PF}{746}$	$\frac{1.732 \times E \times I \times EFF \times PF}{746}$
Current	$\frac{746 \times hp}{E \times EFF}$	$\frac{746 \times hp}{E \times EFF \times PF}$	$\frac{746 \times hp}{1.732 \times E \times EFF \times PF}$
Efficiency	$\frac{746 \times hp}{E \times I}$	$\frac{746 \times hp}{E \times I \times PF}$	$\frac{746 \times hp}{1.732 \times E \times I \times PF}$
Power Factor	——	$\frac{\text{Input watts}}{E \times I}$	$\frac{\text{Input watts}}{1.732 \times E \times I}$

E = Volts
EFF = Efficiency (decimal)
hp = Horsepower
I = Amperes
PF = Power factor (decimal)

FORMULAS FOR ELECTRICAL CIRCUITS

TO FIND	DIRECT CURRENT	SINGLE PHASE	THREE PHASE
Amperes	$\frac{\text{Watts}}{\text{Volts}}$	$\frac{\text{Watts}}{\text{Volts} \times \text{Power factor}}$	$\frac{\text{Watts}}{1.732 \times \text{Volts} \times \text{Power factor}}$
Volt-Amperes	——	Volts x Amperes	1.732 x Volts x Amperes
Watts	Volts x Amperes	Volts x Amperes x Power factor	1.732 x Volts x Amperes x Power factor

OHMS LAW	CAPACITANCE IN MICROFARADS AT 60 HZ
Ohms = Volts/Amperes (R = E/I) Amperes = Volts/Ohms (I = E/R) Volts = Amperes x Ohms (E = IR)	Capacitance = $\frac{2650 \times \text{Amperes}}{\text{Volts}}$ Capacitance = $\frac{2.65 \times \text{kVAR}}{(\text{Volts})^2}$

TEMPERATURE CORRECTION OF WINDING RESISTANCE

$$R_C = R_H \times \frac{(K + T_C)}{(K + T_H)}$$

$$R_H = R_C \times \frac{(K + T_H)}{(K + T_C)}$$

VALUE OF K	
Material	**K**
Aluminum	225
Copper	234.5

R_C = Resistance at temperature T_C (Ohms)

R_H = Resistance at temperature T_H (Ohms)

T_C = Temperature of cold winding (° C)

T_H = Temperature of hot winding (° C)

MOTOR APPLICATION FORMULAS

OUTPUT

$$\text{Horsepower} = \frac{\text{Torque (lb·ft)} \times \text{rpm}}{5252} \qquad \text{Kilowatts} = \frac{\text{Torque (N·m)} \times \text{rpm}}{9550}$$

$$\text{Torque (lb·ft)} = \frac{\text{Horsepower} \times 5252}{\text{rpm}} \qquad \text{Torque (N·m)} = \frac{\text{Kilowatts} \times 9550}{\text{rpm}}$$

For approximation, use:

Full-load torque = 1.5 ft•lb per hp per pole pair at 60 Hz

Full-load torque = 3.2 N•m per kilowatt per pole pair at 50 hZ

TIME FOR MOTOR TO REACH OPERATING SPEED

$$\text{Seconds} = \frac{Wk^2(\text{lb} \cdot \text{ft}^2) \times \text{Speed change (rpm)}}{308 \times \text{Avg. accelerating torque (lb} \cdot \text{ft)}}$$

$$\text{Seconds} = \frac{J(\text{kg} \cdot \text{m}^2) \times \text{Speed change (rpm)}}{9.55 \times \text{Avg. accelerating torque (N} \cdot \text{m)}}$$

$1\ \text{lb} \cdot \text{ft}^2 = .04214\ \text{kg} \cdot \text{m}^2$

$1\ \text{kg} \cdot \text{m}^2 = 23.73\ \text{lb} \cdot \text{ft}^2$

$$\left.\begin{matrix} Wk^2 \\ J \end{matrix}\right\} = \text{Inertia of rotor} + \frac{\text{Inertia of load} \times \text{Load rpm}^2}{\text{Motor rpm}^2}$$

$$\text{Average accelerating torque} = \frac{[(\text{FLT} + \text{BDT})/2] + \text{BDT} + \text{LRT}}{3}$$

Where: BDT = Breakdown torque
FLT = Full-load torque
LRT = Locked-rotor torque

CONVERSION FACTORS

	MULTIPLY		BY		TO OBTAIN
Length	Centimeters	x	.3937	=	Inches
	Feet	x	12.0	=	Inches
	Feet	x	.3048	=	Meters
	Inches	x	2.54	=	Centimeters
	Inches	x	25.4	=	Millimeters
	Kilometers	x	.6214	=	Miles
	Meters	x	3.281	=	Feet
	Meters	x	39.37	=	Inches
	Meters	x	1.094	=	Yards
	Miles	x	5280.0	=	Feet
	Miles	x	1.609	=	Kilometers
	Millimeters	x	.03937	=	Inches
	Yards	x	.9144	=	Meters
Area	Circular mils	x	7.854×10^{-7}	=	Square inches
	Circular mils	x	.7854	=	Square mils
	Square centimeters	x	.155	=	Square inches
	Square feet	x	144.0	=	Square inches
	Square feet	x	.0929	=	Square meters
	Square inches	x	6.452	=	Square centimeters
	Square meters	x	10.764	=	Square feet
	Square meters	x	1.196	=	Square yards
	Square millimeters	x	.00155	=	Square inches
	Square mils	x	1.273	=	Circular mils
	Square yards	x	.8361	=	Square meters
Volume	Cubic centimeters	x	.061	=	Cubic inches
	Cubic feet	x	.0283	=	Cubic meters
	Cubic feet	x	7.481	=	Gallons
	Cubic inches	x	.5541	=	Ounces (fluid)
	Cubic meters	x	35.31	=	Cubic feet
	Cubic meters	x	1.308	=	Cubic yards
	Cubic meters	x	264.2	=	Gallons
	Cubic yards	x	.7646	=	Cubic meters
	Gallons	x	.1337	=	Cubic feet
	Gallons	x	3.785	=	Liters
	Liters	x	.2642	=	Gallons
	Liters	x	1.057	=	Quarts (liquid)
	Ounces (fluid)	x	1.805	=	Cubic inches
	Quarts (liquid)	x	.9463	=	Liters