Section II
Small (Fractional) and Medium (Integral) Machines
Part 12
Tests and Performance—AC and DC Motors

12.1 Scope

The standards in this Part 12 of Section II cover the following machines:

a. Alternating-Current Motors

Alternating-current motors up to and including the ratings in the table below:

Synchronous Speed	Motors Squirrel-Cage and Wound Rotor, Hp	Motors, Synchronous, Hp Power Factor	
		Unity	0.8
3600	500	500	400
1800	500	500	400
1200	350	350	300
900	250	250	200
720	200	200	150
600	150	150	125
514	125	125	100

b. Direct-Current Motors

Direct-current motors built in frames with continuous dripproof ratings, or equivalent capacities, up to and including 1.25 horsepower per rpm, open type.

12.2 High-Potential Test—Safety Precautions and Test Procedure

See 3.1.

12.3 High-Potential Test Voltages for Universal, Induction, and Direct-Current Motors

The high-potential test voltage specified in the following table shall be applied to the windings of each new machine in accordance with the test procedures specified in 3.1.

Category	Effective Test Voltage
a. UNIVERSAL MOTORS (rated for operation on circuits not exceeding 250 volts)	
1. Motors rated greater than 1/2 horsepower and all motors for portable tools	1000 volts + 2 times the rated voltage of the motor, but in no case less than 1500 volts
2. All other motors*	1500 volts
b. INDUCTION AND NONEXCITED SYNCHRONOUS MOTORS	
1. Motors rated greater than 1/2 horsepower	
a) Stator windings	1000 volts + 2 times the rated voltage of the motor, but in no case less than 1500 volts
b) For secondary windings of wound rotors of induction motors	1000 volts + 2 times the maximum voltage induced between collector rings on open circuit at standstill (or running if under this condition the voltage is greater) with rated primary voltage applied to the stator terminals, but in no case less than 1500 volts
c) For secondary windings of wound rotors of reversing motors	1000 volts + 4 times the maximum voltage induced between collector rings on open circuit at standstill with rated primary voltage applied to the stator terminals, but in no case less than 1500 volts
2. Motors rated 1/2 horsepower and less	
a) Rated 250 volts or less	1500 volts
b) Rated above 250 volts	1000 volts + 2 times the rated voltage of the motor, but in no case less than 1500 volts
c. DIRECT-CURRENT MOTORS	
1. Motors rated greater than 1/2 horsepower	
a) Armature or field windings for use on adjustable-voltage electronic power supply	1000 volts + 2 times the ac line-to-line voltage of the power supply selected for the basis of rating, but in no case less than 1500 volts
b) All other armature or field windings	1000 volts + 2 times the rated voltage** of the motor, but in no case less than 1500 volts
2. Motors rated 1/2 horsepower and less	
a) 240 volts or less	1500 volts
b) Rated above 240 volts	See C.1.a and C.1.b above (Direct-Current Motors)

*Complete motors 1/2 horsepower and less shall be in the "all other" category unless marked to indicate that they are motors for portable tools.

**Where the voltage rating of a separately excited field of a direct-current motor or generator is not stated, it shall be assumed to be 1.5 times the field resistance in ohms at 25°C times the rated field current.

NOTES:

1. Certain applications may require a high-potential test voltage higher than those specified.
2. The normal production high-potential test voltage may be 1.2 times the specified 1-minute high-potential test voltage, applied for 1 second (see 3.1.6).
3. To avoid excessive stressing of the insulation, repeated application of the high-potential test-voltage is not recommended. Immediately after manufacture, when equipment is installed or assembled with other apparatus and a high-potential test of the entire assembly is required, it is recommended that the test voltage not exceed 80 percent of the original test voltage or when in an assembled group, not exceed 80 percent of the lowest test voltage of that group (see 3.1.11).

12.4 Production High-Potential Testing of Small Motors

Dielectric failure in high-potential production testing of small motors shall be indicated by a measurement of insulation resistance less than 1 megohm when tested in accordance with 12.2 and 12.3.

12.4.1 Dielectric Test Equipment

The dielectric test equipment should indicate a failure by visual or audible means, or both. The test equipment should preferably be designed to limit the level of applied current to a nondestructive value at the high-potential voltage.

12.4.2 Evaluation of Insulation Systems by a Dielectric Test

The definition of dielectric failure per ASTM D149 is based upon observation of actual rupture of insulation as positive evidence of voltage breakdown. In small motors, a suitable evaluation of insulation quality in production testing may be made without complete rupture of the insulation to ground. As a quality control procedure during manufacture, measurement of the insulation resistance may be taken as a true evaluation of the effectiveness of the insulation system.

12.5 Repetitive Surge Test for Small and Medium Motors

Many manufacturers use a repetitive test as a quality control test for the components of motors (for example, stators and rotors). When a large number of motors of a single design are to be tested, a repetitive surge test is a quick and economical test to make to detect the following faults:

a. Grounded windings
b. Short circuits between turns
c. Short circuits between windings
d. Incorrect connections
e. Incorrect number of turns
f. Misplaced conductors or insulation

The repetitive surge test compares an unknown winding with a known winding, or a winding assumed to be satisfactory. This is accomplished by superimposing on an oscilloscope the traces of the surge voltage at the terminals of the windings. Major faults are easily detected but a skilled operator is required to distinguish between minor faults; for example, a slipped slot cell and the harmless deviations in the traces which occur when windings are produced by two or more operators who place the coils or form the end turns in slightly different ways.

Unfortunately, the repetitive surge test has disadvantages which limit its general usage, such as the necessity for elaborate preliminary tests before a surge test can be made on production units. For example, voltage distribution through the winding should be investigated because resonant conditions may exist which would cause abnormally high or low stresses at some point in the insulation system of the motor component. Elaborate preliminary tests can seldom be justified when a small number of components are involved because comparatively small changes in design may require additional preliminary tests. When a repetitive surge test is made, the surge voltage level and other test conditions should be based upon data obtained from laboratory tests made on the particular design (or designs) of the motors involved.

When a rotor or stator has two or more identical windings, for example, a polyphase stator, each winding may be tested against the other because it is unlikely that any two of the windings will have identical faults. To make it practicable to surge test rotors or stators of similar motor designs one at a time, it is essential that sufficient data be accumulated by the preliminary tests on several individual designs. When a rotor or stator does not have two identical windings, for example, single-phase stators and direct-current armatures, a minimum of two of the same components is required for the repetitive surge test. In the event a fault is disclosed by the test, a minimum of three units is required to determine which one had the fault. It should be noted that, except by undertaking extensive comparative breakdown tests, there is at present no satisfactory way of determining the surge test voltage equivalent to a 60 hertz high-potential test.

12.6 Mechanical Vibration

See Part 7.

12.7 Bearing Losses—Vertical Pump Motors

The added losses in horsepower in angular contact bearings used on vertical pump motors, due to added load over that incurred by the motor rotor, should be calculated by the following formula:

Added losses in horsepower = 2.4 x 10^{-8} x added load in lbs. x revolutions per minute x pitch diameter in inches of the balls in the ball bearing.

Section II
Small (Fractional) and Medium (Integral) Machines
Part 12
Tests and Performance—AC Motors

12.0 Scope

The standards in this Part 12 of Section II cover alternating-current motors up to and including the ratings in the table below.

Synchronous Speed	Motors Squirrel-Cage and Wound Rotor, Hp	Motors, Synchronous, Hp Power Factor		Generators, Synchronous Revolving Field Type, kW at 0.8 Power Factor
		Unity	0.8	
3600	500	500	400	400
1800	500	500	400	400
1200	350	350	300	300
900	250	250	200	200
720	200	200	150	150
600	150	150	125	125
514	125	125	100	100

12.30 Test Methods

Tests to determine performance characteristics shall be made in accordance with the following:

a. For single-phase motors—IEEE Std 114
b. For polyphase induction motors—IEEE Std 112

12.31 Performance Characteristics

When performance characteristics are provided, they should be expressed as follows:

a. Current in amperes or percent of rated current
b. Torque in pound-feet, pound-inches, ounce-feet, ounce-inches, or percent of full-load torque

c. Output in horsepower or percent of rated horsepower
d. Speed in revolutions per minute or percent of synchronous speed
e. Efficiency in percent
f. Power factor in percent
g. Voltage in volts or percent of rated voltage
h. Input power in watts or kilowatts

NOTE: If SI units are used, they should be in accordance with ISO Publication No. R-1000.

12.32 Torque Characteristics of Single-Phase General-Purpose Induction Motors

12.32.1 Breakdown Torque

The breakdown torque of single-phase general-purpose small and medium induction motors shall be within the torque range as given in Table 10-5, subject to tolerances in manufacturing and all other conditions given in 10.34.

12.32.2 Locked-Rotor Torque of Small Motors

The locked-rotor torque of single-phase general-purpose small motors with rated voltage and frequency applied shall be not less than the following:

Hp	Minimum Locked-Rotor Torque, ounce-feet*					
	60 Hertz Synchronous Speed, Rpm			50 Hertz Synchronous Speed, Rpm		
	3600	1800	1200	3000	1500	1000
1/8	—	24	32	—	29	39
1/6	15	33	43	18	39	51
1/4	21	46	59	25	55	70
1/3	26	57	73	31	69	88
1/2	37	85	100	44	102	120
3/4	50	119	—	60	143	—
1	61	—	—	73	—	—

*On the high voltage connection of dual voltage motors, minimum locked-rotor torques up to 10% less than these values might be expected.

12.32.3 Locked-Rotor Torque of Medium Motors

The locked-rotor torque of single-phase general-purpose medium motors with rated voltage and frequency applied shall be not less than the following:

Hp	Minimum Locked-Rotor Torque, pound-feet		
	Synchronous Speed, Rpm		
	3600	1800	1200
3/4	...	...	8.0
1	...	9.0	9.5
1½	4.5	12.5	13.0
2	5.5	16.0	16.0
3	7.5	22.0	23.0
5	11.0	33.0	...
7½	16.0	45.0	...
10	21.0	52.0	...

12.32.4 Pull-Up Torque of Medium Motors

The pull-up torque of single-phase general-purpose alternating-current medium motors with rated voltage and frequency applied shall be not less than the rated load torque.

12.33 Locked-Rotor Current of Single-Phase Small Motors

12.33.1 Design O and Design N Motors

The locked-rotor current of 60 hertz, single-phase motors shall not exceed the values given in the following table:

2-, 4-, 6-, and 8-Pole, 60 Hertz Motors, Single Phase				
Hp	Locked-Rotor Current, Amperes			
	115 Volts		230 Volts	
	Design O	Design N	Design O	Design N
1/6 and smaller	50	20	25	12
1/4	50	26	25	15
1/3	50	31	25	18
1/2	50	45	25	25
3/4	—	61	—	35
1	—	80	—	45

12.33.2 General-Purpose Motors

The locked-rotor currents of single-phase general-purpose motors shall not exceed the values for Design N motors.

12.34 Locked-Rotor Current of Single-Phase Medium Motors, Designs L and M

The locked-rotor current of single-phase, 60 hertz, Design L and M motors of all types, when measured with rated voltage and frequency impressed and with the rotor locked, shall not exceed the following values:

Hp	Locked-Rotor Current, Amperes		
	Design L Motors		Design M Motors
	115 Volts	230 Volts	230 Volts
1/2	45	25	—
3/4	61	35	—
1	80	45	—
1½	—	50	40
2	—	65	50
3	—	90	70
5	—	135	100
7½	—	200	150
10	—	260	200

12.35 Locked-Rotor Current of 3-Phase Small and Medium Squirrel-Cage Induction Motors

12.35.1 60 Hertz Design B Fire Pump Motors at 230 Volts

The locked-rotor current (and the locked-rotor kVA code) of single-speed, 3-phase, NEMA Design B constant-speed induction motors that are fire pump motors, rated at 230 volts, shall not exceed the values listed in Table 12-1A when measured with rated voltage and frequency impressed and with the rotor locked.

12.35.2 60 Hertz Design B, C, and D Motors at 230 Volts

The locked-rotor current (and the locked-rotor kVA code) of single-speed, 3-phase, NEMA Design B, C, and D constant-speed induction motors, rated at 230 volts, shall not exceed the values listed in Table 12-1B when measured with rated voltage and frequency impressed and with the rotor locked.

Table 12-1A
Maximum Locked-Rotor Current (and Maximum Locked-Rotor kVA Code) for 60 Hz Design B Motors at 230 Volts—Applicable to Fire Pump Motors

Hp	Locked-Rotor Current, Amperes*	Design Letters	Locked-Rotor kVA Code
1/2	20	B, D	R
3/4	25	B, D	P
1	30	B, C, D	N
1-1/2	40	B, C, D	M
2	50	B, C, D	L
3	64	B, C, D	K
5	92	B, C, D	J
7-1/2	127	B, C, D	H
10	162	B, C, D	H
15	232	B, C, D	G
20	290	B, C, D	G
25	365	B, C, D	G
30	435	B, C, D	G
40	580	B, C, D	G
50	725	B, C, D	G
60	870	B, C, D	G
75	1085	B, C, D	G
100	1450	B, C, D	G
125	1815	B, C, D	G
150	2170	B, C, D	G
200	2900	B, C	G
250	3650	B	G
300	4400	B	G
350	5100	B	G
400	5800	B	G
450	6500	B	G
500	7250	B	G

*The maximum value of locked-rotor current permitted for motors designed for voltages other than 230 volts shall be inversely proportional to the voltages.

Table 12-1B
Maximum Locked-Rotor Current (and Maximum Locked-Rotor kVA Code) for 60 Hz Design B, C, and D Motors at 230 Volts—Excluding Fire Pump Motors

Hp	Locked-Rotor Current, Amperes*†	Design Letters	Locked-Rotor kVA Code
1/2	20.0	B, D	R
3/4	26.3	B, D	P
1	31.3	B, C, D	N
1-1/2	40.0	B, C, D	M
2	50.0	B, C, D	L
3	64.3	B, C, D	K
5	100	B, C, D	J
7-1/2	131	B, C, D	H
10	175	B, C, D	H
15	236	B, C, D	G
20	315	B, C, D	G
25	394	B, C, D	G
30	473	B, C, D	G
40	631	B, C, D	G
50	789	B, C, D	G
60	947	B, C, D	G
75	1184	B, C, D	G
100	1578	B, C, D	G
125	1973	B, C, D	G
150	2368	B, C, D	G
200	3157	B, C	G
250	3947	B	G
300	4736	B	G
350	5526	B	G
400	6315	B	G
450	7105	B	G
500	7894	B	G

*The maximum value of locked-rotor current permitted for motors designed for voltages other than 230 volts shall be inversely proportional to the voltages.

†The values in the “Locked-Rotor Current, Amperes” column are the lesser of the following two values:

i) The value that results when the locked-rotor kVA per horsepower is the maximum allowable value for the applicable locked-rotor kVA code letter.

ii) the value that results when the locked-rotor kVA per horsepower is determined in accordance with voltage, current, and horsepower values specified in NEMA ICS 2-2000 (R2005, R2020) and the following instructions provided in (1) through (3):

(1) Determine the kVA at each value of voltage and corresponding locked-rotor current in Tables 2-4-1 and 2-4-3 of NEMA ICS 2-2000 (R2005, R2020) for the appropriately sized three-phase, single-speed, full voltage magnetic controller.

(2) Divide each value of kVA in (1) by the applicable horsepower in Table 12-1B and determine the minimum kVA/HP.

(3) $\text{Locked rotor amps} = \frac{(\text{Minimum value determined in }(2))\ \text{X}\ (1000)\ \text{X}\ (\text{applicable horsepower from Table 12–1B})}{\sqrt{3}\ \text{X}\ 230}$

12.35.3 50 Hertz Design B Fire Pump Motors at 380 Volts

The locked-rotor current (and the locked-rotor kVA code) of single-speed, 3-phase, constant-speed NEMA Design B induction motors that are fire pump motors, rated at 380 volts, shall not exceed the values listed in Table 12-1C when measured with rated voltage and frequency impressed and with the rotor locked.

12.35.4 50 Hertz Design B, C, and D Motors at 380 Volts

The locked-rotor current (and the locked-rotor kVA code) of single-speed, 3-phase, constant-speed NEMA Design B, C, and D induction motors, not including fire pump motors, rated at 380 volts, shall not exceed the values shown in Table 12-1D when measured with rated voltage and frequency impressed and with the rotor locked.

Table 12-1C
Maximum Locked-Rotor Current (and Maximum Locked-Rotor kVA Code) for 50 Hz Design B Motors at 380 Volts—Applicable to Fire Pump Motors

Hp	Locked-Rotor Current, Amperes*	Locked-Rotor kVA Code
1/2	20	V
3/4	20	S
1	20	P
1-1/2	27	N
2	34	N
3	43	L
5	61	K
7-1/2	84	J
10	107	H
15	154	H
20	194	H
25	243	H
30	289	H
40	387	H
50	482	H
60	578	H
75	722	H
100	965	H
125	1207	H
150	1441	H
200	1927	H
250	2534	H
300	3026	H
350	3542	H
400	4046	H
450	4539	H
500	5069	H

*The maximum value of locked-rotor current permitted for motors designed for voltages other than 380 volts shall be inversely proportional to the voltages.

Table 12-1D
Maximum Locked-Rotor Current (and Maximum Locked-Rotor kVA Code) for 50 Hz Design B, C, and D Motors at 380 Volts—Excluding Fire Pump Motors

Hp	Locked-Rotor Current, Amperes*†	Design Letters	Locked-Rotor kVA Code
1/2	20.0	B, D	V
3/4	20.4	B, D	S
1	21.2	B, C, D	P
1-1/2	28.4	B, C, D	N
2	34.0	B, C, D	M
3	45.5	B, C, D	L
5	68.2	B, C, D	K
7-1/2	91.0	B, C, D	J
10	107	B, C, D	H
15	161	B, C, D	H
20	215	B, C, D	H
25	269	B, C, D	H
30	323	B, C, D	H
40	430	B, C, D	H
50	538	B, C, D	H
60	646	B, C, D	H
75	807	B, C, D	H
100	1077	B, C, D	H
125	1346	B, C, D	H
150	1615	B, C, D	H
200	2154	B, C	H
250	2693	B	H
300	3231	B	H
350	3770	B	H
400	4308	B	H
450	4847	B	H
500	5386	B	H

*The maximum value of locked-rotor current permitted for motors designed for voltages other than 380 volts shall be inversely proportional to the voltages.

†Each value in the "Locked-Rotor Current, Amperes" column is the value that results in the locked-rotor kVA per horsepower being the maximum allowable value for the applicable locked-rotor kVA code letter.

12.36 Instantaneous Peak Value of Inrush Current

The values in the previous tables are rms symmetrical values, i.e., average of the three phases. There will be a one-half cycle instantaneous peak value which may range from 1.8 to 2.8 times the above values as a function of the motor design and switching angle. This is based upon an ambient temperature of 25°C.

12.37 Torque Characteristics of Polyphase Small Motors

The breakdown torque of a general-purpose polyphase squirrel-cage small motor, with rated voltage and frequency applied, shall be not less than 140 percent of the breakdown torque of a single-phase general-purpose small motor of the same horsepower and speed rating given in 12.32.

NOTE: The speed at breakdown torque is ordinarily much lower in small polyphase motors than in small single-phase motors. Higher breakdown torques are required for polyphase motors so that polyphase and single-phase motors will have interchangeable running characteristics, rating for rating, when applied to normal single-phase motor loads.

12.38 Locked-Rotor Torque of Single-Speed Polyphase Squirrel-Cage Medium Motors with Continuous Ratings

12.38.1 Design A and B Motors

The locked-rotor torque of Design A and B, 60 and 50 hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the values shown in Table 12-2, which are expressed in percent of full-load torque. For applications involving higher torque requirements, see 12.38.2 and 12.38.3 for locked-rotor torque values for Design C and D motors.

Table 12-2
Locked-Rotor Torque of Design A and B, 60 and 50 Hertz
Single-Speed Polyphase Squirrel-Cage Medium Motors

	Synchronous Speed, Rpm						
60 Hertz	**3600**	**1800**	**1200**	**900**	**720**	**600**	**514**
50 Hertz	**3000**	**1500**	**1000**	**750**	—	—	—
1/2 **Hp**	—	—	—	140	140	115	110
3/4	—	—	175	135	135	115	110
1	—	—	170	135	135	115	110
1-1/2	175	250	165	130	130	115	110
2	170	235	160	130	125	115	110
3	160	215	155	130	125	115	110
5	150	185	150	130	125	115	110
7-1/2	140	175	150	125	120	115	110
10	135	165	150	125	120	115	110
15	130	160	140	125	120	115	110
20	130	150	135	125	120	115	110
25	130	150	135	125	120	115	110
30	130	150	135	125	120	115	110
40	125	140	135	125	120	115	110
50	120	140	135	125	120	115	110
60	120	140	135	125	120	115	110
75	105	140	135	125	120	115	110
100	105	125	125	125	120	115	110
125	100	110	125	120	115	115	110
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	—	—	—	—	—
500	70	80	—	—	—	—	—

12.38.2 Design C Motors

The locked-rotor torque of Design C, 60 and 50 hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the values shown in Table 12-3 which are expressed in percent of full-load torque.

Table 12-3
Locked-Rotor Torque of Design C Motors

	Synchronous Speed, Rpm		
60 Hz	**1800**	**1200**	**900**
50 Hz	**1500**	**1000**	**750**
1 **Hp**	285	255	225
1.5	285	250	225
2	285	250	225
3	270	250	225
5	255	250	225
7.5	250	225	200
10	250	225	200
15	225	210	200
20-200	200	200	200

12.38.3 Design D Motors

The locked-rotor torque of Design D, 60 and 50 hertz, 4-, 6-, and 8-pole, single-speed polyphase squirrel-cage medium motors rated 150 horsepower and smaller, with rated voltage and frequency applied, shall be not less than 275 percent, expressed in percent of full-load torque.

12.39 Breakdown Torque of Single-Speed Polyphase Squirrel-Cage Medium Motors with Continuous Ratings

12.39.1 Design A and B Motors

The breakdown torque of Design A and B, 60 and 50 hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

Synchronous Speed, Rpm							
60 Hertz	**3600**	**1800**	**1200**	**900**	**720**	**600**	**514**
50 Hertz	**3000**	**1500**	**1000**	**750**	—	—	—
½ **Hp**	—	—	—	225	200	200	200
3/4	—	—	275	220	200	200	200
1	—	300	265	215	200	200	200
1-1/2	250	280	250	210	200	200	200
2	240	270	240	210	200	200	200
3	230	250	230	205	200	200	200
5	215	225	215	205	200	200	200
7-1/2	200	215	205	200	200	200	200
10-125, inclusive	200	200	200	200	200	200	200
150	200	200	200	200	200	200	—
200	200	200	200	200	200	—	—
250	175	175	175	175	—	—	—
300-350	175	175	175	—	—	—	—
400-500, inclusive	175	175	—	—	—	—	—

12.39.2 Design C Motors

The breakdown torque of Design C, 60 and 50 hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values, which are expressed in percent of full-load torque:

Hp	Synchronous Speed, Rpm			
	60 Hertz	1800	1200	900
	50 Hertz	1500	1000	750
1/2		200	225	200
3/4		200	225	200
1		200	225	200
1-1/2		200	225	200
2		200	225	200
3		200	225	205
5		200	225	205
7-1/2 - 20		200	190	190
25-200, inclusive		190	190	190

12.40 Pull-Up Torque of Single-Speed Polyphase Squirrel-Cage Medium Motors with Continuous Ratings

12.40.1 Design A and B Motors

The pull-up torque of Design A and B, 60 and 50 hertz single-speed, polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

Hp	Synchronous Speed, Rpm						
	60 Hz 3600	1800	1200	900	720	600	514
	50 Hz 3000	1500	1000	750	—	—	—
1/2	—	—	—	100	100	100	100
3/4	—	—	120	100	100	100	100
1	—	190	120	100	100	100	100
1-1/2	120	175	115	100	100	100	100
2	120	165	110	100	100	100	100
3	110	150	110	100	100	100	100
5	105	130	105	100	100	100	100
7-1/2	100	120	105	100	100	100	100
10	100	115	105	100	100	100	100
15	100	110	100	100	100	100	100
20	100	105	100	100	100	100	100
25	100	105	100	100	100	100	100
30	100	105	100	100	100	100	100
40	100	100	100	100	100	100	100
50	100	100	100	100	100	100	100
60	100	100	100	100	100	100	100
75	95	100	100	100	100	100	100
100	95	100	100	100	100	100	100
125	90	100	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	—	—	—	—	—
500	65	75	—	—	—	—	—

12.40.2 Design C Motors

The pull-up torque of Design C 60 and 50 hertz, single speed, polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values, which are expressed in percent of full-load torque:

	Synchronous Speed, Rpm		
60 Hertz	**1800**	**1200**	**900**
50 Hertz	**1500**	**1000**	**750**
1 **Hp**	195	180	165
1-1/2	195	175	160
2	195	175	160
3	180	175	160
5	180	175	160
7-1/2	175	165	150
10	175	165	150
15	165	150	140
20	165	150	140
25	150	150	140
30	150	150	140
40	150	150	140
50	150	150	140
60	140	140	140
75	140	140	140
100	140	140	140
125	140	140	140
150	140	140	140

12.41 Breakdown Torque of Polyphase Wound-Rotor Medium Motors with Continuous Ratings

The breakdown torques of 60 and 50 hertz, polyphase wound-rotor medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

Hp		Breakdown Torque, Percent of Full-Load Torque		
		Synchronous Speed, Rpm		
	60 Hz	**1800**	**1200**	**900**
	50 Hz	**1500**	**1000**	**750**
1		—	—	250
1-1/2		—	—	250
2		275	275	250
3		275	275	250
5		275	275	250
7-1/2		275	275	225
10		275	250	225
15		250	225	225
20-200 inclusive		225	225	225

12.42 Temperature Rise for Small and Universal Motors

Temperatures for 12.42.1 and 12.42.2 shall be determined in accordance with the following:

a. For single-phase motors—IEEE Std 114
b. For polyphase induction motors—IEEE Std 112

12.42.1 Alternating-Current Small Motors—Motor Nameplates Marked with Insulation System Designation and Ambient Temperature

The temperature rise above the temperature of the cooling medium (See note 3), for each of the various parts of the motor shall not exceed the values given in the following table when tested in accordance with the rating, except that for motors having a service factor greater than 1.0, the temperature rise shall not exceed the values given in the following table when tested at the service factor load:

Class of Insulation System (see 1.65)	**A**	**B**	**F***	**H***
Time Rating (see 10.36)				
Temperature Rise (based on a maximum ambient temperature of 40°C), Degrees C				
a. Windings				
1. Open motors other than those given in items a.2 and a.5 – resistance or thermocouple	60	80	105	125
2. Open motors with 1.15 or higher service factor – resistance or thermocouple	70	90	115	—
3. Totally enclosed nonventilated motors, including variations thereof – resistance or thermocouple	65	85	110	130
4. Totally enclosed fan-cooled motors, including variations thereof – resistance or thermocouple	65	85	110	135
5. Any motor in a frame smaller than the 42 frame – resistance or thermocouple	65	85	110	135

*Where a Class F or H insulation system is used, special consideration should be given to bearing temperatures, lubrication, etc.

NOTES:

1. Abnormal deterioration of insulation may be expected if the ambient temperature of 40°C is exceeded in regular operation. See 12.42.3.
2. The foregoing values of temperature rise are based upon operation at altitudes of 3300 feet (1000 meters) or less. For temperature rises for motors intended for operation at altitudes above 3300 feet (1000 meters), see 14.4.
3. For open machines, the temperature of the cooling air is the average temperature of the air entering the machine. For totally enclosed air-cooled machines, the temperature of the cooling air is the average temperature of the air entering the chamber of the external cooling fan. For totally enclosed non-ventilated machines, the temperature of the cooling air is the temperature of the air surrounding the machine. For machines ventilated by air obtained from a remote source or a heat exchanger, the cooling air is the average temperature of the air entering the machine or entering the heat exchanger when part of the machine.

12.42.2 Universal Motors

The temperature rise above the temperature of the cooling medium (See note 3), for each of the various parts of the motor when tested in accordance with the rating, shall not exceed the values given in the following table:

Class of Insulation System (see 1.65)	A	B	F*	H*
Time Rating (see 10.36)				
Temperature Rise (based on a maximum ambient temperature of 40°C), Degrees C				
a. Windings				
1. Open motors – resistance or thermocouple	60	80	105	125
2. Totally enclosed nonventilated motors, including variations thereof – thermocouple or resistance	65	85	110	130
3. Totally enclosed fan-cooled motors, including variations thereof – resistance or thermocouple	65	85	110	135

*Where a Class F or H insulation system is used, special consideration should be given to bearing temperatures, lubrication, etc.

NOTES:

1. Abnormal deterioration of insulation may be expected if the ambient temperature of 40°C is exceeded in regular operation. See 12.42.3.
2. The foregoing values of temperature rise are based upon operation at altitudes of 3300 feet (1000 meters) or less. For temperature rises for motors intended for operation at altitudes above 3300 feet (1000 meters), see 14.4.
3. For open machines, the temperature of the cooling air is the average temperature of the air entering the machine. For totally enclosed air-cooled machines, the temperature of the cooling air is the average temperature of the air entering the chamber of the external cooling fan. For totally enclosed non-ventilated machines, the temperature of the cooling air is the temperature of the air surrounding the machine. For machines ventilated by air obtained from a remote source or a heat exchanger, the cooling air is the average temperature of the air entering the machine or entering the heat exchanger when part of the machine.

12.42.3 Temperature Rise for Ambients Higher than 40ºC

The temperature rises given in 12.42.1 and 12.42.2 are based upon a reference ambient temperature of 40°C. However, it is recognized that induction machines may be required to operate in an ambient temperature higher than 40°C. For successful operation of induction machines in ambient temperatures higher than 40°C, the temperature rises of the machines given in 12.42.1 and 12.42.2 shall be reduced by the number of degrees that the ambient temperature exceeds 40°C. When a higher ambient temperature than 40ºC is required, preferred values of ambient temperatures are 50°C, 65°C, 90°C, and 115°C.

12.42.4 Temperature Rise for Air-Cooled Machines for Ambients Lower than 40º C, but Not Below 0º C*

The temperature rises given in 12.42.1 and 12.42.2 are based upon a reference ambient temperature of 40°C to cover most general environments. However, it is recognized that air-cooled induction machines may be operated in environments where the ambient temperature of the cooling air will always be less than 40°C. When an air-cooled induction machine is marked with a maximum ambient less than 40°C then the allowable temperature rises in 12.42.1 and 12.42.2 shall be increased according to the following:

a. For machines for which the difference between the Reference Temperature and the sum of 40°C and the Temperature Rise Limit given in 12.42.1 and 12.42.2 is less than or equal to 5°C then the temperature rises given in 12.42.1 and 12.42.2 shall be increased by the amount of the difference between 40ºC and the lower marked ambient temperature.

b. For machines for which the difference between the Reference Temperature and the sum of 40°C and the Temperature Rise Limit given in 12.42.1 and 12.42.2 is greater than 5°C then the temperature rises given in 12.42.1 and 12.42.2 shall be increased by the amount calculated from the following expression:

$$\text{Increase in Rise} = \{40°\text{C} - \text{Marked Ambient}\}\ \text{x}\ \left\{1 - \frac{[(\text{Reference Temperature} - (40°\text{C} + \text{Temperature Rise Limit})]}{80°\text{C}}\right\}$$

Where:

	Class of Insulation System			
	A	B	F	H
Reference Temperature for SF less than 1.15, Degrees C	105	130	155	180
Reference Temperature for 1.15 SF or higher, Degrees C	115	140	165	190

NOTE: This requirement does not include water-cooled machines.

Temperature Rise Limit = maximum allowable temperature rise according to 12.42.1 and 12.42.2

For example: A 1.0 service factor rated open motor with a Class F insulation system is marked for use in an ambient with a maximum temperature of 25°C. From the Table above the Reference Temperature is 155ºC and from 12.42.1 the Temperature Rise Limit is 105°C. The allowable Increase in Rise to be added to the Temperature Rise Limit is then:

$$\text{Increase in Rise} = \{40°\text{C} - 25°\text{C}\}\ \text{x}\ \left\{1 - \frac{155°\text{C} - (40°\text{C} + 105°\text{C})}{80°\text{C}}\right\} = 13°\text{C}$$

The total allowable Temperature Rise by Resistance above a maximum of a 25ºC ambient is then equal to the sum of the Temperature Rise Limit from 12.42.1 and the calculated Increase in Rise. For this example, that total is 105ºC + 13ºC = 118°C.

12.43 Temperature Rise for Medium Single-Phase and Polyphase Induction Motors

The temperature rise, above the temperature of the cooling medium, (See note 3), for each of the various parts of the motor shall not exceed the values given in the following table when tested in accordance with the rating, except that for motors having a service factor 1.15 or higher, the temperature rise shall not exceed the values given in the following table when tested at the service factor load. Temperatures shall be determined in accordance with the following:

a. For single-phase motors—IEEE Std 114
b. For polyphase induction motors—IEEE Std 112

Class of Insulation System (see 1.65)	A	B	F*	H*†
Time Rating (shall be continuous or any short-time rating given in 10.36)				
Temperature Rise (based on a maximum ambient temperature of 40°C), Degrees C				
a. Windings, by resistance method				
1. Motors with 1.0 service factor other than those given in items a.3 and a.4	60	80	105	125
2. All motors with 1.15 or higher service factor	70	90	115	—
3. Totally-enclosed nonventilated motors with 1.0 service factor	65	85	110	130
4. Motors with encapsulated windings and with 1.0 service factor, all enclosures	65	85	110	—
b. The temperatures attained by cores, squirrel-cage windings, and miscellaneous parts (such as brushholders, brushes, pole tips, etc.) shall not injure the insulation or the machine in any respect				

*Where a Class F or H insulation system is used, special consideration should be given to bearing temperatures, lubrication, etc.
†This column applies to polyphase motors only.

NOTES:

1. Abnormal deterioration of insulation may be expected if the ambient temperature of 40°C is exceeded in regular operation. See 12.43.1.
2. The foregoing values of temperature rise are based upon operation at altitudes of 3300 feet (1000 meters) or less. For temperature rises for motors intended for operation at altitudes above 3300 feet (1000 meters), see 14.4.
3. For open machines, the temperature of the cooling air is the average temperature of the air entering the machine. For totally enclosed air-cooled machines, the temperature of the cooling air is the average temperature of the air entering the chamber of the external cooling fan. For totally enclosed non-ventilated machines, the temperature of the cooling air is the temperature of the air surrounding the machine. For machines ventilated by air obtained from a remote source or a heat exchanger, the cooling air is the average temperature of the air entering the machine or entering the heat exchanger when part of the machine.

12.43.1 Temperature Rise for Ambients Higher than 40ºC

The temperature rises given in 12.43 are based upon a reference ambient temperature of 40°C. However, it is recognized that induction machines may be required to operate in an ambient temperature higher than 40°C. For successful operation of induction machines in ambient temperatures higher than 40°C, the temperature rises of the machines given in 12.43 shall be reduced by the number of degrees that the ambient temperature exceeds 40°C. When a higher ambient temperature than 40ºC is required, preferred values of ambient temperatures are 50°C, 65°C, 90°C, and 115°C.

12.43.2 Temperature Rise for Air-Cooled Machines for Ambients Lower than 40° C, but Not Below 0° C*

The temperature rises given in 12.43 are based upon a reference ambient temperature of 40°C to cover most general environments. However, it is recognized that air-cooled induction machines may be operated in environments where the ambient temperature of the cooling air will always be less than 40°C. When an air-cooled induction machine is marked with a maximum ambient less than 40°C then the allowable temperature rises in 12.43 shall be increased according to the following:

a. For machines for which the difference between the Reference Temperature and the sum of 40°C and the Temperature Rise Limit given in 12.43 is less than or equal to 5°C then the temperature rises given in 12.43 shall be increased by the amount of the difference between 40ºC and the lower marked ambient temperature.

b. For machines for which the difference between the Reference Temperature and the sum of 40°C and the Temperature Rise Limit given in 12.43 is greater than 5°C then the temperature rises given in 12.43 shall be increased by the amount calculated from the following expression:

$$\text{Increase in Rise} = \{40°\text{C} - \text{Marked Ambient}\} \text{ x } \left\{1 - \frac{\text{Reference Temperature} - [(40°\text{C} + \text{Temperature Rise Limit})]}{80°\text{C}}\right\}$$

Where:

	Class of Insulation System			
	A	B	F	H
Reference Temperature for SF less than 1.15, Degrees C	105	130	155	180
Reference Temperature for 1.15 SF or higher, Degrees C	115	140	165	190

NOTE: This requirement does not include water-cooled machines.

Temperature Rise Limit = maximum allowable temperature rise according to 12.43

For example: A 1.0 service factor rated open motor with a Class F insulation system is marked for use in an ambient with a maximum temperature of 25°C. From the table above the Reference Temperature is 155ºC and from 12.43 the Temperature Rise Limit is 105°C. The allowable Increase in Rise to be added to the Temperature Rise Limit is then:

$$\text{Increase in Rise} = \{40°\text{C} - 25°\text{C}\} \text{ x } \left\{1 - \frac{155°\text{C} - (40°\text{C} + 105°\text{C})}{80°\text{C}}\right\} = 13°\text{C}$$

The total allowable Temperature Rise by Resistance above a maximum of a 25ºC ambient is then equal to the sum of the Temperature Rise Limit from 12.43 and the calculated Increase in Rise. For this example, that total is 105ºC + 13ºC = 118°C.

12.44 Variation from Rated Voltage and Rated Frequency

12.44.1 Running

Alternating-current motors shall operate successfully under running conditions at rated load with a variation in the voltage or the frequency up to the following:

a. Plus or minus 10 percent of rated voltage with rated frequency for induction motors.
b. Plus or minus 6 percent of rated voltage with rated frequency for universal motors.
c. Plus or minus 5 percent of rated frequency with rated voltage.
d. A combined variation in voltage and frequency of 10 percent (sum of absolute values) of the rated values, provided the frequency variation does not exceed plus or minus 5 percent of rated frequency, and the voltage variation of universal motors (except fan motors) does not exceed plus or minus 6 percent of rated voltage.

Performance within these voltage and frequency variations will not necessarily be in accordance with the standards established for operation at rated voltage and frequency.

12.44.2 Starting

Medium motors shall start and accelerate to running speed a load which has a torque characteristic and an inertia value not exceeding that listed in 12.54 with the voltage and frequency variations specified in 12.44.1.

The limiting values of voltage and frequency under which a motor will successfully start and accelerate to running speed depend on the margin between the speed-torque curve of the motor at rated voltage and frequency and the speed-torque curve of the load under starting conditions. Since the torque developed by the motor at any speed is approximately proportional to the square of the voltage and inversely proportional to the square of the frequency, it is generally desirable to determine what voltage and frequency variations will actually occur at each installation, taking into account any voltage drop resulting from the starting current drawn by the motor. This information and the torque requirements of the driven machine define the motor-speed-torque curve, at rated voltage and frequency, which is adequate for the application.

12.45 Voltage Unbalance

Alternating-current polyphase motors shall operate successfully under running conditions at rated load when the voltage unbalance at the motor terminals does not exceed 1 percent. Performance will not necessarily be the same as when the motor is operating with a balanced voltage at the motor terminals (see 14.36).

12.46 Variation from Rated Speed

The variation from the nameplate or published data speed of alternating-current, single-phase and polyphase, medium motors shall not exceed 20 percent of the difference between synchronous speed and rated speed when measured at rated voltage, frequency, and load and with an ambient temperature of 25°C.

12.47 Nameplate Amperes—Alternating-Current Medium Motors

When operated at rated voltage, rated frequency, and rated horsepower output, the input in amperes shall not vary from the nameplate value by more than 10 percent.

12.48 Occasional Excess Current

Polyphase motors having outputs not exceeding 500 horsepower (according to this part) and rated voltages not exceeding 1kV shall be capable of withstanding a current equal to 1.5 times the full load rated current for not less than two minutes when the motor is initially at normal operating temperature.

Repeated overloads resulting in prolonged operation at winding temperatures above the maximum values given by 12.43 will result in reduced insulation life.

12.49 Stall Time

Polyphase motors having outputs not exceeding 500 horsepower and rated voltage not exceeding 1kV shall be capable of withstanding locked-rotor current for not less than 12 seconds when the motor is initially at normal operating temperatures.

Motors specially designed for inertia loads greater than those in Table 12-7 shall be marked on the nameplate with the permissible stall time in seconds.

12.50 Performance of Small and Medium Polyphase Motors with Single, Dual, or Broad Range Voltage Rating

When a small or medium polyphase motor is marked with a single (e.g., 230 V), dual (e.g., 230/460), or broad range (e.g., 208-230) voltage in the Voltage field, the motor shall meet all performance requirements of MG 1, such as efficiency, at the rated voltage(s).

When a voltage is shown on a nameplate field (e.g., “Useable at 200 Volts” per 14.35.2 or “Useable at 208 Volts”) other than the Voltage field, the motor is not required to meet all performance requirements of this standard (e.g., torques and nameplate nominal efficiency) at this other voltage. These requirements apply only to the rated voltage(s) shown in the Voltage field.

12.51 Service Factor of Alternating-Current Motors

12.51.1 General-Purpose Alternating-Current Motors of the Open Type

When operated at rated voltage and frequency, general-purpose alternating-current motors of the open type shall have a service factor in accordance with Table 12-4 (see 14.37).

Table 12-4
Service Factors

Hp	Service Factor Synchronous Speed, Rpm							
	3600	1800	1200	900	720	600	514	
1/20	1.4	1.4	1.4	1.4	—	—	—	Small Motors
1/12	1.4	1.4	1.4	1.4	—	—	—	
1/8	1.4	1.4	1.4	1.4	—	—	—	
1/6	1.35	1.35	1.35	1.35	—	—	—	
1/4	1.35	1.35	1.35	1.35	—	—	—	
1/3	1.35	1.35	1.35	1.35	—	—	—	
1/2	1.25	1.25	1.25	1.15*	—	—	—	Medium Motors
3/4	1.25	1.25	1.15*	1.15*	—	—	—	
1	1.25	1.15*	1.15*	1.15*	—	—	—	
1-1/2-125	1.15*	1.15*	1.15*	1.15*	1.15*	1.15*	1.15*	
150	1.15*	1.15*	1.15*	1.15*	1.15*	1.15*	—	
200	1.15*	1.15*	1.15*	1.15*	1.15*	—	—	
250	1.0	1.15*	1.15*	1.15*	—	—	—	
300	1.0	1.15*	1.15*	—	—	—	—	
350	1.0	1.15*	1.15*	—	—	—	—	
400	1.0	1.15*	—	—	—	—	—	
450	1.0	1.15*	—	—	—	—	—	
500	1.0	1.15*	—	—	—	—	—	

*In the case of polyphase squirrel-cage motors, these service factors apply only to Design A, B, and C motors.

12.51.2 Other Motors

When operated at rated voltage and frequency, other open-type and all totally enclosed alternating-current motors shall have a service factor of 1.0.

In those applications requiring an overload capacity, the use of a higher horsepower rating, as given in 10.32.4, is recommended to avoid exceeding the temperature rises for the class of insulation system used and to provide adequate torque capacity.

12.52 Overspeeds for Motors

12.52.1 Squirrel-Cage and Wound-Rotor Motors

Squirrel-cage and wound-rotor induction motors, except crane motors, shall be so constructed that in an emergency not to exceed 2 minutes, they will withstand without mechanical injury overspeeds above synchronous speed in accordance with the following. During this overspeed condition the machine is not electrically connected to the supply.

Hp	Synchronous Speed, Rpm	Overspeed, Percent of Synchronous Speed
200 and smaller	1801 and over	25
	1201 to 1800	25
	1200 and below	50
250-500, incl.	1801 and over	20
	1800 and below	25

12.52.2 General-Purpose Squirrel-Cage Induction Motors

General-purpose squirrel-cage induction motors for the ratings specified in Table 12-5 and horsepower per frame assignments per Part 13 shall be mechanically constructed so as to be capable of operating continuously at the rated load at speeds not less than the speed indicated in Table 12-5 when directly coupled. Those motors for which this speed is greater than synchronous speed at 60 Hz shall be capable of withstanding overspeed, not to exceed 2 minutes of 10 percent above the speed indicated in Table 12-5 without mechanical damage. For motors where the speed in Table 12-5 is equal to synchronous speed at 60 Hz, the overspeed limits in 12.52.1 shall apply, assuming the motor is not energized when the overspeed occurs.

Table 12-5 does not apply to motors used in belted applications. For belted applications, consult the motor manufacturer.

Table 12-5
Continuous Speed Capability for General-Purpose Squirrel-Cage Induction Motors in Direct Coupled Applications, Except Those Motors in Table 12-6

Hp	Totally Enclosed Fan-Cooled			Open Dripproof		
	Synchronous Speed at 60 Hz					
	3600	1800	1200	3600	1800	1200
	Minimum Design Speed					
1/4	5200	3600	2400	5200	3600	2400
1/3	5200	3600	2400	5200	3600	2400
1/2	5200	3600	2400	5200	3600	2400
3/4	5200	3600	2400	5200	3600	2400
1	5200	3600	2400	5200	3600	2400
1.5	5200	3600	2400	5200	3600	2400
2	5200	3600	2400	5200	3600	2400
3	5200	3600	2400	5200	3600	2400
5	5200	3600	2400	5200	3600	2400
7.5	4500	2700	2400	5200	2700	2400
10	4500	2700	2400	4500	2700	2400
15	4500	2700	2400	4500	2700	2400
20	4500	2700	2400	4500	2700	2400
25	4500	2700	1800	4500	2700	1800
30	4500	2700	1800	4500	2700	1800
40	3600	2300	1800	4500	2300	1800
50	3600	2300	1800	3600	2300	1800
60	3600	2300	1800	3600	2300	1800
75	3600	2300	1800	3600	2300	1800
100	3600	2300	1800	3600	2300	1800
125	3600	2300	1800	3600	2300	1800
150	3600	2300	1800	3600	2300	1800
200	3600	2300	1800	3600	2300	1800
250	3600	2300	1200	3600	2300	1200
300	3600	1800	1200	3600	2300	1200
350	3600	1800	1200	3600	1800	1200
400	3600	1800	—	3600	1800	—
450	3600	1800	—	3600	1800	—
500	3600	1800	—	3600	1800	—

12.52.3 General-Purpose Design A and B Direct-Coupled Squirrel-Cage Induction Motors

General-purpose Design A and B (TS shaft for motors above the 250 frame size) squirrel-cage induction motors for the ratings specified in Table 12-6 and horsepower per frame assignments per Part 13 shall be capable of operating mechanically constructed so as to be capable of operating continuously at the rated load at speeds not less than the speed indicated in Table 12-6 when directly coupled. Those motors for which this speed is greater than the synchronous speed at 60 Hz shall be capable of withstanding overspeeds, not to exceed 2 minutes of 10 percent above the speed indicated in Table 12-6 without mechanical damage. For motors where the speed in Table 12-6 is equal to synchronous speed at 60 Hz, the overspeed limits in 12.52.1 shall apply, assuming the motor is not energized when the overspeed occurs.

Table 12-6 does not apply to motors used in belted applications. For belted applications consult the motor manufacturer.

12.52.4 Alternating-Current Series and Universal Motors

Alternating-current series and universal motors shall be so constructed that, in an emergency not to exceed 2 minutes, they will withstand without mechanical injury an overspeed of 10 percent above the no-load speed[1] at rated voltages.

[1] For motors which are integrally attached to loads that cannot become accidentally disconnected, the words “no-load speed” shall be interpreted to mean the lightest load condition possible with the load.

Table 12-6
Continuous Speed Capability for General-Purpose Design A and B Direct Coupled (TS Shaft for Motors Above The 250 Frame Size) Squirrel-Cage Induction Motors

Horsepower	Totally Enclosed Fan-Cooled			Open Dripproof		
	Synchronous Speed at 60 Hz					
	3600	1800	1200	3600	1800	1200
	Minimum Design Speed					
1/4	7200	3600	2400	7200	3600	2400
1/3	7200	3600	2400	7200	3600	2400
1/2	7200	3600	2400	7200	3600	2400
3/4	7200	3600	2400	7200	3600	2400
1	7200	3600	2400	7200	3600	2400
1.5	7200	3600	2400	7200	3600	2400
2	7200	3600	2400	7200	3600	2400
3	7200	3600	2400	7200	3600	2400
5	7200	3600	2400	7200	3600	2400
7.5	5400	3600	2400	7200	3600	2400
10	5400	3600	2400	5400	3600	2400
15	5400	3600	2400	5400	3600	2400
20	5400	3600	2400	5400	3600	2400
25	5400	2700	2400	5400	2700	2400
30	5400	2700	2400	5400	2700	2400
40	4500	2700	2400	5400	2700	2400
50	4500	2700	2400	4500	2700	2400
60	3600	2700	2400	4500	2700	2400
75	3600	2700	2400	3600	2700	2400
100	3600	2700	1800	3600	2700	1800
125	3600	2700	1800	3600	2700	1800
150	3600	2700	1800	3600	2700	1800
200	3600	2300	1800	3600	2700	1800
250	3600	2300	1800	3600	2300	1800
300	3600	2300	1800	3600	2300	1800
350	3600	1800	1800	3600	1800	1800
400	3600	1800	-	3600	1800	-
450	3600	1800	-	3600	1800	-
500	3600	1800	-	3600	1800	-

12.53 Machine Sound (Medium Induction Motors)

See Part 9 for Sound Power Limits and Measurement Procedures.

12.54 Number of Starts

12.54.1 Normal Starting Conditions

Design A and B squirrel-cage induction motors having horsepower ratings given in 10.32.4 and performance characteristics in accordance with this Part 12 shall be capable of accelerating without injurious heating load Wk^2 referred to the motor shaft equal to or less than the values listed in Table 12-7 under the following conditions:

a. Applied voltage and frequency in accordance with 12.44.
b. 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-load torque at rated speed.
c. Two starts in succession (coasting to rest between starts) with the motor initially at the ambient temperature or one start with the motor initially at a temperature not exceeding its rated load operating temperature.

Table 12-7
Squirrel-Cage Induction Motors

Hp	Synchronous Speed, Rpm						
	3600	1800	1200	900	720	600	514
	Load Wk² (Exclusive of Motor Wk²), Lb-Ft²						
1	—	5.8	15	31	53	82	118
1½	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
7½	8.3	39	104	208	355	551	799
10	11	51	137	273	467	723	1050
15	16	75	200	400	684	1060	1540
20	21	99	262	525	898	1390	2020
25	26	122	324	647	1110	1720	2490
30	30	144	384	769	1320	2040	2960
40	40	189	503	1010	1720	2680	3890
50	49	232	620	1240	2130	3300	4790
60	58	275	735	1470	2520	3920	5690
75	71	338	904	1810	3110	4830	7020
100	92	441	1180	2370	4070	6320	9190
125	113	542	1450	2920	5010	7790	11300
150	133	640	1720	3460	5940	9230	—
200	172	831	2240	4510	7750	—	—
250	210	1020	2740	5540	—	—	—
300	246	1200	3240	—	—	—	—
350	281	1370	3720	—	—	—	—
400	315	1550	—	—	—	—	—
450	349	1710	—	—	—	—	—
500	381	1880	—	—	—	—	—

The values of Wk^2 of connected load given in Table 12-7 were calculated from the following formula and larger values rounded to three significant figures:

$$\text{Load Wk}^2 = A\left[\frac{\text{Hp}^{0.95}}{\left(\frac{\text{RPM}}{1000}\right)^{2.4}}\right] - 0.0685\left[\frac{\text{Hp}^{1.5}}{\left(\frac{\text{RPM}}{1000}\right)^{1.8}}\right]$$

Where:

A = 24 for 300 to 1800 rpm motors, inclusive
A = 27 for 3600 rpm motors

12.54.2 Other than Normal Starting Conditions

If the starting conditions are other than those stated in 12.54.1, the motor manufacturer should be consulted.

12.54.3 Considerations for Additional Starts

When additional starts are required, it is recommended that none be made until all conditions affecting operation have been thoroughly investigated and the apparatus examined for evidence of excessive heating. It should be recognized that the number of starts should be kept to a minimum since the life of the motor is affected by the number of starts.

12.55 Routine Tests for Polyphase Medium Induction Motors

12.55.1 Method of Testing

The method of testing polyphase induction motors shall be in accordance with IEEE Std 112.

12.55.2 Typical Tests on Completely Assembled Motors

Typical tests which may be made on motors completely assembled in the factory and furnished with shaft and complete set of bearings are as follows:

a. Measurement of winding resistance.
b. No-load readings of current and speed at normal voltage and frequency. On 50 hertz motors, these readings may be taken at 60 hertz.
c. Current input at rated frequency with rotor at standstill for squirrel-cage motors. This may be taken single-phase or polyphase at rated or reduced voltage. (When this test is made single-phase, the polyphase values of a duplicate machine should be given in any report). On 50 hertz motors, these readings may be taken at 60 hertz.
d. Measurement of open-circuit voltage ratio on wound-rotor motors.
e. High-potential test in accordance with 3.1 and 12.3.

12.55.3 Typical of Tests on Motors Not Completely Assembled

Typical tests which may be made on all motors not completely assembled in the factory are as follows.

a. Measurement of winding resistance.
b. High-potential test in accordance with 3.1 and 12.3.

12.56 Thermal Protection of Medium Motors

The protector in a thermally protected motor shall limit the winding temperature and the ultimate trip current as follows:

12.56.1 Winding Temperature

12.56.1.1 Running Load

When a motor marked “Thermally Protected” is running at the maximum continuous load that it can carry without causing the protector to open the circuit, the temperature of the windings shall not exceed the temperature shown in Table 12-8.

Table 12-8
Winding Temperatures

Insulation System Class	Maximum Winding Temperature, Degrees C
A	140
B	165
F	190
H	215

Tests shall be conducted at any ambient temperature within the range of 10°C to 40°C.

The temperature of the windings shall be measured by the resistance method except that, for motors rated 15 horsepower and smaller, the temperature shall be permitted to be measured by the thermocouple method as an alternative.

Short-time rated motors and motors for intermittent duty shall be permitted to be run at no-load and reduced voltage if necessary, for a continuous running test to verify that the protector is able to limit the temperatures to those given in the Table 12-8.

12.56.1.2 Locked Rotor

When a motor marked "Thermally Protected" is under locked-rotor conditions, the thermal protector shall cycle to limit the winding temperature to the values given in Table 12-9.

The test for motors with automatic-reset thermal protectors shall be run until temperature peaks are constant or for 72 hours, whichever is shorter.

The test for motors with manual-reset thermal protectors shall be 10 cycles, the protector being reclosed as quickly as possible after it opens. If ten cycles are completed in less than 1 hour, only the "During first hour" limits given in Table 12-9 apply.

Table 12-9
Winding Temperature Under Locked-Rotor Conditions, Degrees C

Type of Protector	Maximum Temperature, Degrees C* Insulation System Class				Average Temperature, **Degrees C* Insulation System Class			
	A	B	F	H	A	B	F	H
Automatic reset								
During first hour	200	225	250	275	—	—	—	—
After first hour	175	200	225	250	150	175	200	225
Manual reset								
During first hour	200	225	250	275	—	—	—	—
After first hour	175	200	225	250	—	—	—	—

* Test shall be permitted to be conducted at any ambient temperature within the range of 10°C to 40°C.

** The average temperature is the average of the average peak and average reset winding temperatures. The average temperature shall be within limits during both the second and last hours of the test.

12.56.2 Trip Current

A motor rated more than 1 horsepower and marked "Thermally Protected" shall have an ultimate trip current, based on a 40°C ambient temperature, not in excess of the following percentages of motor full-load currents:

Motor Full-Load Amperes	Trip Current as a Percent of Motor Full-Load Current
9.0 and less	170
Over 9.0 but not over 20.0	156
Over 20.0	140

Dual-voltage motors shall comply with the ultimate trip current requirements for both voltages.

12.57 Overtemperature Protection of Medium Motors Not Meeting the Definition of "Thermally Protected"

Motors rated above 1 horsepower and marked "OVER TEMP PROT-" are provided with winding overtemperature protection devices or systems which do not meet the definition of "Thermally Protected".

The motors marked "OVER TEMP PROT-" shall be followed by the numeral 1, 2, or 3 stamped in the blank space to indicate the type of winding overtemperature protection provided. For each type, the winding overtemperature protector shall limit the temperature of the winding as follows:

12.57.1 Type 1—Winding Running and Locked-Rotor Overtemperature Protection

12.57.1.1 Winding Running Temperature

When the motor is marked "OVER TEMP PROT-1" and is running at the maximum continuous load which it can carry without causing the winding overtemperature protector to operate, the temperature of the windings shall not exceed the temperature shown in Table 12-8.

The temperature of the windings shall be measured by the resistance method except that, for motors rated 15 horsepower and smaller, the temperature shall be permitted to be measured by the thermocouple method.

12.57.1.2 Winding Locked-Rotor Temperature

In addition, when the motor is marked "OVER TEMP PROT-1" and is under locked-rotor conditions, the winding overtemperature protector shall limit the temperature of the windings to the values shown in Table 12-8.

12.57.2 Type 2—Winding Running Overtemperature Protection

When the motor is marked "OVER TEMP PROT-2" and is running at the maximum continuous load which it can carry without causing the winding overtemperature protector to operate, the temperature of the windings shall not exceed the temperature shown in Table 12-8. When the motor is so marked, locked-rotor protection is not provided by the winding overtemperature protector.

12.57.3 Type 3—Winding Overtemperature Protection, Nonspecific Type

When the motor is marked "OVER TEMP PROT-3," the motor manufacturer shall be consulted for details of protected conditions or winding temperatures, or both.

12.58 Efficiency

12.58.1 Determination of Motor Efficiency and Losses

Efficiency and losses shall be determined in accordance with IEEE Std 112, IEC 60034-2-1, CSA Std C390, IEEE Std 114 or CSA Std C747. The efficiency shall be determined at rated output, voltage, and frequency.

Unless otherwise specified, horizontal single-phase, squirrel-cage small motors of the capacitor-start induction-run or capacitor-start capacitor-run type rated 1/4 to 3 horsepower shall be tested as described in IEEE Std 114[2].

Unless otherwise specified, horizontal polyphase, squirrel-cage motors rated 1/4 horsepower or greater and less than 1 horsepower shall be tested by Method A as described in IEEE Std 112 or the equivalent CSA C747 test procedure. Motor efficiency shall be calculated using form A of IEEE Std 112 or the equivalent CSA C747 calculation procedure.

Unless otherwise specified, horizontal polyphase, squirrel-cage motors rated 1 to 500 horsepower shall be tested by (Method B)[3] as described in IEEE Std 112. Motor efficiency shall be calculated using form B of IEEE Std 112 or IEC 60034-2-1 (Method 2-1-1B), or the equivalent CSA C390 calculation procedure. Vertical motors of this horsepower range shall also be tested by Method B if bearing construction permits; otherwise they shall be tested by segregated losses (Method E) as described in IEEE Std 112, including direct measurement of stray-load loss.

The following losses shall be included in determining the efficiency:

a. Stator I^2R
b. Rotor I^2R
c. Core loss
d. Stray load loss
e. Friction and windage loss[4]
f. Brush contact loss of wound-rotor machines

Power required for auxiliary items, such as external pumps or fans, that are necessary for the operation of the motor shall be stated separately.

[2] CSA 747

[3] IEC 60034-2-1 Method 2-1-1B or CSA 390

[4] In the case of a motor furnished with less than a full set of bearings – perform the test by adding standard bearings (6000 series, single-row, deep groove, radial ball bearings that are either open or grease-lubricated double-shielded).

In the case of a motor furnished with a thrust bearing -

i) The motor may be tested with the thrust bearing replaced by a standard bearing (6000 series, single-row, deep groove, radial ball bearings that are either open or grease-lubricated double-shielded). The efficiency may be reported with no adjustments.

ii) The motor may be tested with the thrust bearing. The additional loss of the thrust bearing over the loss of the standard bearing, determined by calculation or experience, may be removed from the friction and windage loss, thus adjusting the reported efficiency.

iii) The motor may be tested with the thrust bearing. The efficiency may be reported with no adjustments.

iv) A calculated value of efficiency, including thrust bearing loss due to an external thrust load, may be reported. The manufacturer shall declare in which method the machine was tested.

In determining I^2R losses at all loads, the resistance of each winding shall be corrected to a temperature equal to an ambient temperature of 25°C plus the observed rated load temperature rise measured by resistance. When the rated load temperature rise has not been measured, the resistance of the winding shall be corrected to the following temperature:

Class of Insulation System	Temperature, Degrees C
A	75
B	95
F	115
H	130

If the rated temperature rise is specified as that of a lower class of insulation system, the temperature for resistance correction shall be that of the lower insulation class.

12.58.2 Efficiency of Squirrel-Cage Small and Medium Motors with Continuous Ratings

The full-load efficiency of Design N single-speed single-phase squirrel-cage small motors of the capacitor- start induction-run or capacitor-start capacitor-run type in the range of 1/4 through 3 horsepower shall be identified on the nameplate by a nominal efficiency selected from the Nominal Efficiency column in Table 12-10, which shall be not greater than the average efficiency of a large population of motors of the same design.

The full-load efficiency of Design L and M single-speed single-phase squirrel-cage motors in the range of 1/4 through 3 horsepower shall be identified on the nameplate by a nominal efficiency selected from the Nominal Efficiency column in Table 12-10, which shall be not greater than the average efficiency of a large population of motors of the same design.

The full-load efficiency of 60 Hz Design A and B single-speed polyphase squirrel-cage medium motors in the range of 1 (0.75kW) through 500 horsepower (375kW), and equivalent 60 Hz Design C ratings shall be identified on the nameplate by a nominal efficiency selected from the Nominal Efficiency column in Table 12-10, which shall be not greater than the average efficiency of a large population of motors of the same design.

The full-load efficiency of 50 Hz Design A and B single-speed polyphase squirrel-cage medium motors in the range of 1 (0.75 kW) through 500 horsepower (375 kW) and equivalent 50 Hz Design C ratings shall be identified on the nameplate with a value which shall not be greater than the average efficiency of a large population of motors of the same design.

The efficiency of 60 Hz motors shall be identified on the nameplate by the caption “NEMA Nominal Efficiency” or “NEMA Nom. Eff”. The efficiency of 50 Hz motors shall be identified on the nameplate by the caption “Efficiency”, “NEMA Nominal Efficiency”, or “NEMA Nom. Eff”.

The full-load efficiency, when operating at rated voltage and frequency, shall be not less than the minimum value associated with the nominal value in Table 12-10[5].

[5] This requirement is not applicable for 50 Hz motors for which the identified full-load efficiency is not a nominal value selected from Table 12-10.

Table 12-10
Efficiency Levels

Nominal Efficiency	Minimum Efficiency Based on 20% Loss Difference	Nominal Efficiency	Minimum Efficiency Based on 20% Loss Difference
99.0	98.8	91.0	89.5
98.9	98.7	90.2	88.5
98.8	98.6	89.5	87.5
98.7	98.5	88.5	86.5
98.6	98.4	87.5	85.5
98.5	98.2	86.5	84.0
98.4	98.0	85.5	82.5
98.2	97.8	84.0	81.5
98.0	97.6	82.5	80.0
97.8	97.4	81.5	78.5
97.6	97.1	80.0	77.0
97.4	96.8	78.5	75.5
97.1	96.5	77.0	74.0
96.8	96.2	75.5	72.0
96.5	95.8	74.0	70.0
96.2	95.4	72.0	68.0
95.8	95.0	70.0	66.0
95.4	94.5	68.0	64.0
95.0	94.1	66.0	62.0
94.5	93.6	64.0	59.5
94.1	93.0	62.0	57.5
93.6	92.4	59.5	55.0
93.0	91.7	57.5	52.5
92.4	91.0	55.0	50.5
91.7	90.2	52.5	48.0
—	—	50.5	46.0
—	—	48.0	43.5
—	—	46.0	41.0
—	—	43.5	38.5
—	—	41.0	36.5
—	—	38.5	34.5
—	—	36.5	32.5
—	—	34.5	30.5

Variations in materials, manufacturing processes, and tests result in motor-to-motor efficiency variations for a given motor design; the full-load efficiency for a large population of motors of a single design is not a unique efficiency but rather a band of efficiency. Therefore, Table 12-10 has been established to indicate a logical series of nominal motor efficiencies and the minimum associated with each nominal. The nominal efficiency represents a value which should be used to compute the energy consumption of a motor or group of motors.

12.59 Efficiency Levels of Energy-Efficient Polyphase Squirrel-Cage Induction Motors Rated 600 Volts or Less at 60 Hz

For a polyphase squirrel-cage induction motor rated 600 volts or less at 60 Hz to be classified as "energy efficient," the nominal full-load efficiency as determined in accordance with 12.58.1, identified on the nameplate in accordance with 12.58.2, and having a corresponding minimum efficiency in accordance with Table 12-10 shall equal or exceed the appropriate value of nominal efficiency listed in Table 12-11 for motors rated in horsepower or Table 12-15 for motors rated in kilowatts. Table 12-15 is provided as a convenient reference for motors with output ratings marked in accordance with IEC standards.

12.60 Efficiency Levels of Premium Efficiency Electric Motors

12.60.1 Electric Motors Rated 600 Volts or Less

12.60.1.1 Single-Phase Capacitor-Start Induction-Run Small Motors

The nominal full-load efficiency of premium efficiency single-phase capacitor-start induction-run small motors rated 600 volts or less determined in accordance with 12.58.1, identified on the nameplate in accordance with 12.58.2, and having a minimum efficiency in accordance with Table 12- 10 shall equal or exceed the values listed in Table 12-19.

12.60.1.2 Single-Phase Capacitor-Start Capacitor-Run Small Motors

The nominal full-load efficiency of premium efficiency single-phase capacitor-start capacitor-run small motors rated 600 volts or less determined in accordance with 12.58.1, identified on the nameplate in accordance with 12.58.2, and having a minimum efficiency in accordance with Table 12- 10 shall equal or exceed the values listed in Table 12-20.

12.60.1.3 Polyphase Small Motors

The nominal full-load efficiency of premium efficiency polyphase small motors rated 600 volts or less determined in accordance with 12.58.1, identified on the nameplate in accordance with 12.58.2, and having a minimum efficiency in accordance with Table 12-10 shall equal or exceed the values listed in Table 12-21.

12.60.1.4 Polyphase Medium Motors

The nominal full-load efficiency of premium efficiency polyphase medium motors rated 600 volts or less at 60 Hz determined in accordance with 12.58.1, identified on the nameplate in accordance with 12.58.2, and having a minimum efficiency in accordance with Table 12-10 shall equal or exceed the values listed in Table 12-12 for motors rated in horsepower or Table 12-16 for motors rated in kilowatts. Table 12-16 is provided as a convenient reference for motors with output ratings marked in accordance with IEC standards.

12.60.2 60 Hz Polyphase Medium Motors Rated 601–5000 Volts

For a polyphase medium electric motor rated at a voltage of 601 to 5000 volts at 60 Hz to be classified as "premium efficiency," the nominal full-load efficiency as determined in accordance with 12.58.1, identified on the nameplate in accordance with 12.58.2, and having a minimum efficiency in accordance with Table 12-10 shall equal or exceed the values listed in Table 12-13 for motors rated in horsepower or Table 12-17 for motors rated in kilowatts.

Table 12-17 is provided as a convenient reference for motors with output ratings marked in accordance with IEC standards.

12.60.3 50 Hz Polyphase Motors Rated 600 Volts or Less

For a polyphase electric motor rated 600 volts or less at 50 Hz to be classified as "premium efficiency," the full-load efficiency as determined in accordance with 12.58.1 and identified on the nameplate in accordance with 12.58.2 shall equal or exceed the values listed in Table 12-14 for motors rated in horsepower or Table 12-18 for motors rated in kilowatts. Table 12-18 is provided as a convenient reference for motors with output ratings marked in accordance with IEC standards.

The values of efficiency in Table 12-14 for (0.7457 • Hp) ≤ 200 kW were derived based on the following equation[6]:

$$\%\,Efficiency = A * \lfloor log_{10}(0.7457 * Hp) \rfloor^3 + B * \lfloor log_{10}(0.7457 * Hp) \rfloor^2 + C * \lfloor log_{10}(0.7457 * Hp) \rfloor + D$$

Where:

A, B, C, and D = the values given in the following table:

	2 Pole	4 Pole	6 Pole	8 Pole
A	0.3569	0.0773	0.1252	1.0843
B	-3.3076	-1.8951	-2.613	- 5.7229
C	11.6108	9.2984	11.9963	14.9236.
D	82.2503	83.7025	80.4769	77.6700

The above relationship can be used to calculate the efficiency in percent for Hp levels which are not given specifically in Table 12-14.

The values of efficiency in Table 12-18 for kW ≤ 200 were derived based on the following equation:

$$\%\,Efficiency = A * \lfloor log_{10}(kw) \rfloor^3 + B * \lfloor log_{10}(kw) \rfloor^2 + C * \lfloor log_{10}(kw) \rfloor + D$$

Where:

A, B, C, and D = the values given in the table in 12.60.3.

[6] Based on efficiency level IE3 in IEC 60034-30-1.

Table 12-11
Full-Load Efficiencies of 60 Hz Energy-Efficient Motors

Hp	Open Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	—	—	82.5	80.0	80.0	77.0	74.0	70.0
1.5	82.5	80.0	84.0	81.5	84.0	81.5	75.5	72.0
2	84.0	81.5	84.0	81.5	85.5	82.5	85.5	82.5
3	84.0	81.5	86.5	84.0	86.5	84.0	86.5	84.0
5	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
7.5	87.5	85.5	88.5	86.5	88.5	86.5	88.5	86.5
10	88.5	86.5	89.5	87.5	90.2	88.5	89.5	87.5
15	89.5	87.5	91.0	89.5	90.2	88.5	89.5	87.5
20	90.2	88.5	91.0	89.5	91.0	89.5	90.2	88.5
25	91.0	89.5	91.7	90.2	91.7	90.2	90.2	88.5
30	91.0	89.5	92.4	91.0	92.4	91.0	91.0	89.5
40	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60	93.0	91.7	93.6	92.4	93.6	92.4	92.4	91.0
75	93.0	91.7	94.1	93.0	93.6	92.4	93.6	92.4
100	93.0	91.7	94.1	93.0	94.1	93.0	93.6	92.4
125	93.6	92.4	94.5	93.6	94.1	93.0	93.6	92.4
150	93.6	92.4	95.0	94.1	94.5	93.6	93.6	92.4
200	94.5	93.6	95.0	94.1	94.5	93.6	93.6	92.4
250	94.5	93.6	95.4	94.5	95.4	94.5	94.5	93.6
300	95.0	94.1	95.4	94.5	95.4	94.5	—	—
350	95.0	94.1	95.4	94.5	95.4	94.5	—	—
400	95.4	94.5	95.4	94.5	—	—	—	—
450	95.8	95.0	95.8	95.0	—	—	—	—
500	95.8	95.0	95.8	95.0	—	—	—	—

Table 12-11 continued on next page.

Table 12-11 continued

Hp	Enclosed Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	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	74.0	70.0
1.5	82.5	80.0	84.0	81.5	85.5	82.5	77.0	74.0
2.0	84.0	81.5	84.0	81.5	86.5	84.0	82.5	80.0
3.0	85.5	82.5	87.5	85.5	87.5	85.5	84.0	81.5
5.0	87.5	85.5	87.5	85.5	87.5	85.5	85.5	82.5
7.5	88.5	86.5	89.5	87.5	89.5	87.5	85.5	82.5
10.0	89.5	87.5	89.5	87.5	89.5	87.5	88.5	86.5
15.0	90.2	88.5	91.0	89.5	90.2	88.5	88.5	86.5
20.0	90.2	88.5	91.0	89.5	90.2	88.5	89.5	87.5
25.0	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
30.0	91.0	89.5	92.4	91.0	91.7	90.2	91.0	89.5
40.0	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50.0	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60.0	93.0	91.7	93.6	92.4	93.6	92.4	91.7	90.2
75.0	93.0	91.7	94.1	93.0	93.6	92.4	93.0	91.7
100.0	93.6	92.4	94.5	93.6	94.1	93.0	93.0	91.7
125.0	94.5	93.6	94.5	93.6	94.1	93.0	93.6	92.4
150.0	94.5	93.6	95.0	94.1	95.0	94.1	93.6	92.4
200.0	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
250.0	95.4	94.5	95.0	94.1	95.0	94.1	94.5	93.6
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	—	—	—	—

Table 12-12
Full-Load Efficiencies for 60 Hz Premium Efficiency Polyphase Electric Motors
Rated 600 Volts or Less

Hp	Open Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84.0	81.5	86.5	84.0	86.5	84.0	77.0	74.0
2	85.5	82.5	86.5	84.0	87.5	85.5	86.5	84.0
3	85.5	82.5	89.5	87.5	88.5	86.5	87.5	85.5
5	86.5	84.0	89.5	87.5	89.5	87.5	88.5	86.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5	89.5	87.5
10	89.5	87.5	91.7	90.2	91.7	90.2	90.2	88.5
15	90.2	88.5	93.0	91.7	91.7	90.2	90.2	88.5
20	91.0	89.5	93.0	91.7	92.4	91.0	91.0	89.5
25	91.7	90.2	93.6	92.4	93.0	91.7	91.0	89.5
30	91.7	90.2	94.1	93.0	93.6	92.4	91.7	90.2
40	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.4	95.0	94.1	94.5	93.6	93.0	91.7
75	93.6	92.4	95.0	94.1	94.5	93.6	94.1	93.0
100	93.6	92.4	95.4	94.5	95.0	94.1	94.1	93.0
125	94.1	93.0	95.4	94.5	95.0	94.1	94.1	93.0
150	94.1	93.0	95.8	95.0	95.4	94.5	94.1	93.0
200	95.0	94.1	95.8	95.0	95.4	94.5	94.1	93.0
250	95.0	94.1	95.8	95.0	95.8	95.0	95.0	94.1
300	95.4	94.5	95.8	95.0	95.8	95.0	—	—
350	95.4	94.5	95.8	95.0	95.8	95.0	—	—
400	95.8	95.0	95.8	95.0	—	—	—	—
450	96.2	95.4	96.2	95.4	—	—	—	—
500	96.2	95.4	96.2	95.4	—	—	—	—

Table 12-12 continued on next page.

Table 12-12 continued

Hp	Enclosed Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5	78.5	75.5
2	85.5	82.5	86.5	84.0	88.5	86.5	84.0	81.5
3	86.5	84.0	89.5	87.5	89.5	87.5	85.5	82.5
5	88.5	86.5	89.5	87.5	89.5	87.5	86.5	84.0
7.5	89.5	87.5	91.7	90.2	91.0	89.5	86.5	84.0
10	90.2	88.5	91.7	90.2	91.0	89.5	89.5	87.5
15	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
20	91.0	89.5	93.0	91.7	91.7	90.2	90.2	88.5
25	91.7	90.2	93.6	92.4	93.0	91.7	90.2	88.5
30	91.7	90.2	93.6	92.4	93.0	91.7	91.7	90.2
40	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.4	95.0	94.1	94.5	93.6	92.4	91.0
75	93.6	92.4	95.4	94.5	94.5	93.6	93.6	92.4
100	94.1	93.0	95.4	94.5	95.0	94.1	93.6	92.4
125	95.0	94.1	95.4	94.5	95.0	94.1	94.1	93.0
150	95.0	94.1	95.8	95.0	95.8	95.0	94.1	93.0
200	95.4	94.5	96.2	95.4	95.8	95.0	94.5	93.6
250	95.8	95.0	96.2	95.4	95.8	95.0	95.0	94.1
300	95.8	95.0	96.2	95.4	95.8	95.0	—	—
350	95.8	95.0	96.2	95.4	95.8	95.0	—	—
400	95.8	95.0	96.2	95.4	—	—	—	—
450	95.8	95.0	96.2	95.4	—	—	—	—
500	95.8	95.0	96.2	95.4	—	—	—	—

Table 12-13
Full-Load Efficiencies for 60 Hz Premium Efficiency Polyphase Medium Electric Motors
Rated 601 to 5000 Volts

Open Motors								
Hp	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
250	94.5	93.6	95.0	94.1	95.0	94.1	93.6	92.4
300	94.5	93.6	95.0	94.1	95.0	94.1	—	—
350	94.5	93.6	95.0	94.1	95.0	94.1	—	—
400	94.5	93.6	95.0	94.1	—	—	—	—
450	94.5	93.6	95.0	94.1	—	—	—	—
500	94.5	93.6	95.0	94.1	—	—	—	—
Enclosed Motors								
Hp	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
250	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
300	95.0	94.1	95.0	94.1	95.0	94.1	—	—
350	95.0	94.1	95.0	94.1	95.0	94.1	—	—
400	95.0	94.1	95.0	94.1	—	—	—	—
450	95.0	94.1	95.0	94.1	—	—	—	—
500	95.0	94.1	95.0	94.1	—	—	—	—

Table 12-14
Full-Load Efficiencies for 50 Hz Premium Efficiency Polyphase Electric Motors
Rated 600 Volts or Less

Hp	Open and Enclosed Motors		
	2 Pole	4 Pole	6 Pole
1	80.7	82.5	78.9
1.5	82.8	84.2	81.1
2	84.2	85.3	82.5
3	85.9	86.7	84.4
5	87.9	88.4	86.5
7.5	89.2	89.6	88.0
10	90.1	90.4	89.0
15	91.2	91.5	90.3
20	91.9	92.1	91.2
25	92.4	92.6	91.8
30	92.8	93.0	92.2
40	93.3	93.5	92.9
50	93.7	93.9	93.4
60	94.0	94.2	93.7
75	94.3	94.6	94.1
100	94.7	95.0	94.6
125	95.0	95.3	94.9
150	95.2	95.5	95.2
200	95.5	95.8	95.5
250	95.7	95.9	95.7
300	95.8	96.0	95.8
350	95.8	96.0	95.8
400	95.8	96.0	95.8
450	95.8	96.0	95.8
500	95.8	96.0	95.8

Table 12-15 - KW
Full-Load Efficiencies of 60 Hz Energy-Efficient Motors

kW	Open Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
0.75	—	—	82.5	80.0	80.0	77.0	74.0	70.0
1.1	82.5	80.0	84.0	81.5	84.0	81.5	75.5	72.0
1.5	84.0	81.5	84.0	81.5	85.5	82.5	85.5	82.5
2.2	84.0	81.5	86.5	84.0	86.5	84.0	86.5	84.0
3	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
3.7	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
4	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
5.5	87.5	85.5	88.5	86.5	88.5	86.5	88.5	86.5
7.5	88.5	86.5	89.5	87.5	90.2	88.5	89.5	87.5
11	89.5	87.5	91.0	89.5	90.2	88.5	89.5	87.5
15	90.2	88.5	91.0	89.5	91.0	89.5	90.2	88.5
18.5	91.0	89.5	91.7	90.2	91.7	90.2	90.2	88.5
22	91.0	89.5	92.4	91.0	92.4	91.0	91.0	89.5
30	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
37	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
45	93.0	91.7	93.6	92.4	93.6	92.4	92.4	91.0
55	93.0	91.7	94.1	93.0	93.6	92.4	93.6	92.4
75	93.0	91.7	94.1	93.0	94.1	93.0	93.6	92.4
90	93.6	92.4	94.5	93.6	94.1	93.0	93.6	92.4
110	93.6	92.4	95.0	94.1	94.5	93.6	93.6	92.4
132	94.5	93.6	95.0	94.1	94.5	93.6	93.6	92.4
150	94.5	93.6	95.0	94.1	94.5	93.6	93.6	92.4
185	94.5	93.6	95.4	94.5	95.4	94.5	94.5	93.6
200	94.5	93.6	95.4	94.5	95.4	94.5	94.5	93.6
220	95.0	94.1	95.4	94.5	95.4	94.5	—	—
250	95.0	94.1	95.4	94.5	95.4	94.5	—	—
280	95.4	94.5	95.4	94.5	—	—	—	—
300	95.4	94.5	95.4	94.5	—	—	—	—
315	95.4	94.5	95.4	94.5	—	—	—	—
335	95.8	95.0	95.8	95.0	—	—	—	—
355	95.8	95.0	95.8	95.0	—	—	—	—
375	95.8	95.0	95.8	95.0	—	—	—	—
400	95.8	95.0	95.8	95.0	—	—	—	—

Table 12-15 continued next page

Table 12-15 - KW continued

kW	Enclosed Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
0.75	75.5	72.0	82.5	80.0	80.0	77.0	74.0	70.0
1.1	82.5	80.0	84.0	81.5	85.5	82.5	77.0	74.0
1.5	84.0	81.5	84.0	81.5	86.5	84.0	82.5	80.0
2.2	85.5	82.5	87.5	85.5	87.5	85.5	84.0	81.5
3.7	87.5	85.5	87.5	85.5	87.5	85.5	85.5	82.5
5.5	88.5	86.5	89.5	87.5	89.5	87.5	85.5	82.5
7.5	89.5	87.5	89.5	87.5	89.5	87.5	88.5	86.5
11	90.2	88.5	91.0	89.5	90.2	88.5	88.5	86.5
15	90.2	88.5	91.0	89.5	90.2	88.5	89.5	87.5
18.5	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
22	91.0	89.5	92.4	91.0	91.7	90.2	91.0	89.5
30	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
37	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
45	93.0	91.7	93.6	92.4	93.6	92.4	91.7	90.2
55	93.0	91.7	94.1	93.0	93.6	92.4	93.0	91.7
75	93.6	92.4	94.5	93.6	94.1	93.0	93.0	91.7
90	94.5	93.6	94.5	93.6	94.1	93.0	93.6	92.4
110	94.5	93.6	95.0	94.1	95.0	94.1	93.6	92.4
150	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
185	95.4	94.5	95.0	94.1	95.0	94.1	94.5	93.6
200	95.4	94.5	95.0	94.1	95.0	94.1	94.5	93.6
220	95.4	94.5	95.4	94.5	95.0	94.1	—	—
250	95.4	94.5	95.4	94.5	95.0	94.1	—	—
280	95.4	94.5	95.4	94.5	—	—	—	—
300	95.4	94.5	95.4	94.5	—	—	—	—
315	95.4	94.5	95.4	94.5	—	—	—	—
335	95.4	94.5	95.4	94.5	—	—	—	—
355	95.4	94.5	95.8	95.0	—	—	—	—
375	95.4	94.5	95.8	95.0	—	—	—	—
400	95.4	94.5	95.8	95.0	—	—	—	—

Table 12-16 - KW
Full-Load Efficiencies for 60 Hz Premium Efficiency Polyphase Electric Motors
Rated 600 Volts or Less

kW	Open Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
0.75	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.1	84.0	81.5	86.5	84.0	86.5	84.0	77.0	74.0
1.5	85.5	82.5	86.5	84.0	87.5	85.5	86.5	84.0
2.2	85.5	82.5	89.5	87.5	88.5	86.5	87.5	85.5
3.7	86.5	84.0	89.5	87.5	89.5	87.5	88.5	86.5
5.5	88.5	86.5	91.0	89.5	90.2	88.5	89.5	87.5
7.5	89.5	87.5	91.7	90.2	91.7	90.2	90.2	88.5
11	90.2	88.5	93.0	91.7	91.7	90.2	90.2	88.5
15	91.0	89.5	93.0	91.7	92.4	91.0	91.0	89.5
18.5	91.7	90.2	93.6	92.4	93.0	91.7	91.0	89.5
22	91.7	90.2	94.1	93.0	93.6	92.4	91.7	90.2
30	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
37	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
45	93.6	92.4	95.0	94.1	94.5	93.6	93.0	91.7
55	93.6	92.4	95.0	94.1	94.5	93.6	94.1	93.0
75	93.6	92.4	95.4	94.5	95.0	94.1	94.1	93.0
90	94.1	93.0	95.4	94.5	95.0	94.1	94.1	93.0
110	94.1	93.0	95.8	95.0	95.4	94.5	94.1	93.0
150	95.0	94.1	95.8	95.0	95.4	94.5	94.1	93.0
185	95.0	94.1	95.8	95.0	95.8	95.0	95.0	94.1
200	95.0	94.1	95.8	95.0	95.8	95.0	95.0	94.1
220	95.4	94.5	95.8	95.0	95.8	95.0	—	—
250	95.4	94.5	95.8	95.0	95.8	95.0	—	—
280	95.8	95.0	95.8	95.0	—	—	—	—
300	95.8	95.0	95.8	95.0	—	—	—	—
315	95.8	95.0	95.8	95.0	—	—	—	—
335	96.2	95.4	96.2	95.4	—	—	—	—
355	96.2	95.4	96.2	95.4	—	—	—	—
375	96.2	95.4	96.2	95.4	—	—	—	—
400	96.2	95.4	96.2	95.4	—	—	—	—

Table 12-16 continued next page.

Table 12-16 – KW continued

kW	Enclosed Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
0.75	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.1	84.0	81.5	86.5	84.0	87.5	85.5	78.5	75.5
1.5	85.5	82.5	86.5	84.0	88.5	86.5	84.0	81.5
2.2	86.5	84.0	89.5	87.5	89.5	87.5	85.5	82.5
3.7	88.5	86.5	89.5	87.5	89.5	87.5	86.5	84.0
5.5	89.5	87.5	91.7	90.2	91.0	89.5	86.5	84.0
7.5	90.2	88.5	91.7	90.2	91.0	89.5	89.5	87.5
11	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
15	91.0	89.5	93.0	91.7	91.7	90.2	90.2	88.5
18.5	91.7	90.2	93.6	92.4	93.0	91.7	90.2	88.5
22	91.7	90.2	93.6	92.4	93.0	91.7	91.7	90.2
30	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
37	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
45	93.6	92.4	95.0	94.1	94.5	93.6	92.4	91.0
55	93.6	92.4	95.4	94.5	94.5	93.6	93.6	92.4
75	94.1	93.0	95.4	94.5	95.0	94.1	93.6	92.4
90	95.0	94.1	95.4	94.5	95.0	94.1	94.1	93.0
110	95.0	94.1	95.8	95.0	95.8	95.0	94.1	93.0
150	95.4	94.5	96.2	95.4	95.8	95.0	94.5	93.6
185	95.8	95.0	96.2	95.4	95.8	95.0	95.0	94.1
200	95.8	95.0	96.2	95.4	95.8	95.0	95.0	94.1
220	95.8	95.0	96.2	95.4	95.8	95.0	—	—
250	95.8	95.0	96.2	95.4	95.8	95.0	—	—
280	95.8	95.0	96.2	95.4	—	—	—	—
300	95.8	95.0	96.2	95.4	—	—	—	—
315	95.8	95.0	96.2	95.4	—	—	—	—
335	95.8	95.0	96.2	95.4	—	—	—	—
355	95.8	95.0	96.2	95.4	—	—	—	—
375	95.8	95.0	96.2	95.4	—	—	—	—
400	95.8	95.0	96.2	95.4	—	—	—	—

Table 12-17 - KW
Full-Load Efficiencies for 60 Hz Premium Efficiency Polyphase Medium Electric Motors
Rated 601 to 5000 Volts

kW	Open Motors							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
185	94.5	93.6	95	94.1	95	94.1	93.6	92.4
200	94.5	93.6	95	94.1	95	94.1	—	—
220	94.5	93.6	95	94.1	95	94.1	—	—
250	94.5	93.6	95	94.1	95	94.1	—	—
280	94.5	93.6	95	94.1	—	—	—	—
300	94.5	93.6	95	94.1	—	—	—	—
315	94.5	93.6	95	94.1	—	—	—	—
335	94.5	93.6	95	94.1	—	—	—	—
355	94.5	93.6	95	94.1	—	—	—	—
375	94.5	93.6	95	94.1	—	—	—	—
400	94.5	93.6	95	94.1	—	—	—	—
	Enclosed Motors							
kW	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
185	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
200	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
220	95.0	94.1	95.0	94.1	95.0	94.1	—	—
250	95.0	94.1	95.0	94.1	95.0	94.1	—	—
280	95.0	94.1	95.0	94.1	—	—	—	—
300	95.0	94.1	95.0	94.1	—	—	—	—
315	95.0	94.1	95.0	94.1	—	—	—	—
335	95.0	94.1	95.0	94.1	—	—	—	—
355	95.0	94.1	95.0	94.1	—	—	—	—
375	95.0	94.1	95.0	94.1	—	—	—	—
400	95.0	94.1	95.0	94.1	—	—	—	—

Table 12-18 - KW
Full-Load Efficiencies for 50 Hz Premium Efficiency Polyphase Electric Motors Rated 600 Volts or Less (Random Wound)

kW	Efficiency		
	2 Pole	4 Pole	6 Pole
0.75	80.7	82.5	78.9
1.1	82.7	84.1	81.0
1.5	84.2	85.3	82.5
2.2	85.9	86.7	84.3
3	87.1	87.7	85.6
3.7	87.8	88.4	86.5
4	88.1	88.6	86.8
5.5	89.2	89.6	88.0
7.5	90.1	90.4	89.1
11	91.2	91.4	90.3
15	91.9	92.1	91.2
18.5	92.4	92.6	91.7
22	92.7	93.0	92.2
30	93.3	93.6	92.9
37	93.7	93.9	93.3
45	94.0	94.2	93.7
55	94.3	94.6	94.1
75	94.7	95.0	94.6
90	95.0	95.2	94.9
110	95.2	95.4	95.1
132	95.4	95.6	95.4
150	95.5	95.8	95.5
160	95.6	95.8	95.6
185	95.7	95.9	95.7
200 up to 375	95.8	96.0	95.8

Table 12-19
Premium Efficiency Levels for Capacitor-Start/Induction-Run Single-Phase 48 and 56 Frame Motors

Hp	Frame	Efficiency				
		Open Enclosure	Enclosed Enclosure			
		8-pole	2-pole	4-pole	6-pole	8-pole
0.25	48	-	59.5	59.5	57.5	-
	56	-	59.5	59.5	57.5	-
0.33	48	-	64.0	64.0	-	-
	56	50.5	64.0	64.0	62.0	50.5
0.50	48	-	68.0	66.0	-	-
	56	52.5	70.0	70.0	68.0	52.5
0.75	48	-	70.0	70.0	-	-
	56	-	72.0	72.0	70.0	-
1.00	48	-	-	-	-	-
	56	-	72.0	72.0	72.0	-
1.50	48	-	-	-	-	-
	56	-	74.0	74.0	-	-
2.00	48	-	-	-	-	-
	56	-	77.0	-	-	-
3.00	48	-	-	-	-	-
	56	-	-	-	-	-

Table 12-20
Premium Efficiency Levels for Capacitor-Start/Capacitor-Run Single-Phase 48 and 56 Frame Motors

Hp	Frame	Efficiency				
		Open Enclosure	Enclosed Enclosure			
		8-pole	2-pole	4-pole	6-pole	8-pole
0.25	48	55.0	68.0	70.0	64.0	55.0
	56	55.0	68.0	70.0	64.0	55.0
0.33	48	57.5	72.0	72.0	68.0	57.5
	56	59.5	72.0	74.0	68.0	59.5
0.50	48	62.0	72.0	74.0	72.0	62.0
	56	64.0	74.0	77.0	72.0	64.0
0.75	48	—	75.5	75.5	—	—
	56	72.0	77.0	78.5	75.5	72.0
1.00	48	—	77.0	—	—	—
	56	74.0	78.5	80.0	77.0	74.0
1.50	48	—	—	—	—	—
	56	—	81.5	81.5	80.0	—
2.00	48	—	—	—	—	—
	56	—	82.5	82.5	—	—
3.00	48	—	—	—	—	—
	56	—	84.0	—	—	—

Table 12-21
Premium Efficiency Levels for Three-Phase Induction 48 and 56 Frame Motors

Hp	Frame	Efficiency				
		Open Enclosure	Enclosed Enclosure			
		8-pole	2-pole	4-pole	6-pole	8-pole
0.25	48	62.0	66.0	68.0	66.0	62.0
	56	64.0	66.0	70.0	72.0	64.0
0.33	48	64.0	70.0	72.0	70.0	64.0
	56	66.0	72.0	74.0	72.0	66.0
0.50	48	66.0	72.0	75.5	72.0	66.0
	56	68.0	74.0	78.5	75.5	68.0
0.75	48	—	75.5	77.0	74.0	—
	56	70.0	77.0	81.5	81.5	70.0
1.00	48	—	75.5	77.0	74.0	—
	56	75.5	77.0	85.5	82.5	75.5
1.50	48	—	—	82.5	—	—
	56	77.0	84.0	86.5	87.5	78.5
2.00	48	—	—	85.5	—	—
	56	86.5	85.5	86.5	88.5	84.0
3.00	48	—	—	86.5	—	—
	56	87.5	86.5	89.5	89.5	85.5

12.61 Report of Test for Tests on Induction Motors

For reporting routine tests on induction motors, see IEEE Std 112, Appendix A.

12.62 Machine with Encapsulated or Sealed Windings—Conformance Tests

An alternating-current squirrel-cage machine with encapsulated or sealed windings shall be capable of passing the tests listed below.

After the stator winding is completed, join all leads together leaving enough length to avoid creepage to terminals and perform the following tests in the sequence indicated:

a. The encapsulated or sealed stator shall be tested while all insulated parts are submerged in a tank of water containing a wetting agent. The wetting agent shall be non-ionic and shall be added in a proportion sufficient to reduce the surface tension of water to a value of 31 dyn/cm (31×10^3 μN/m) or less at 25°C.
b. Using 500 volts direct-current, take a 10-minute insulation resistance measurement following the procedure as outlined in IEEE Std 43. The minimum insulation resistance in megohms shall be ≥ 5 times the machine rated kilovolts plus 5.
c. Subject the winding to a 60 hertz high potential test of 1.15 times the rated line-to-line rms voltage for 1 minute; Water must be at ground potential during this test.
d. Using 500 volts direct-current, take a 1-minute insulation resistance measurement following the procedure as outlined in IEEE Std 43. The minimum insulation resistance in megohms shall be ≥ 5 times the machine rated kilovolts plus 5.
e. Remove winding from water, rinse if necessary, dry, and apply other tests as may be required.

NOTE: The above test is recommended as a test on a representative sample or prototype and should not be construed as a production test.

12.63 Machine with Moisture Resistant Windings—Conformance Test

An alternating-current squirrel-cage machine with moisture resistant windings shall be capable of passing the following test:

a. After the stator is completed, join all leads together and place it in a chamber with 100 percent relative humidity and 40°C temperature for 168 hours, during which time visible condensation shall be standing on the winding.

b. After 168 hours remove the stator winding from the chamber and within 5 minutes using 500-volt direct current take a 1-minute insulation resistance measurement following the procedure as outlined in IEEE Std 43. The insulation resistance value shall be not less than 1.5 megohms.

NOTES:

1. The above test is recommended as a test on a representative sample or prototype and should not be construed as a production test.

2. The sealed winding conformance test in 20.18 shall be permitted to be used in place of this test procedure to demonstrate moisture resistance of a prototype.

Section II
Small (Fractional) and Medium (Integral) Machines
Part 12
Tests and Performance—DC Small and Medium Motors

12.0 Scope

The standards in this Part 12 of Section II cover direct-current motors built in frames with continuous dripproof ratings, or equivalent capacities, up to and including 1.25 horsepower per rpm open type.

12.65 Test Methods

Tests to determine performance characteristics shall be made in accordance with IEEE Std 113.

12.66 Test Power Supply

12.66.1 Small Motors

Performance tests on direct-current small motors intended for use on adjustable-voltage rectifier power supplies shall be made with an adjustable power supply, derived from a 60 hertz source, that will provide rated voltage and rated form factor at rated load.

12.66.2 Medium Motors

See Figure 12-1.

12.66.2.1 Low-Ripple Power Supplies—Power Supply A

The rating of direct-current motors intended for use on low-ripple power supplies shall be based on the use of one of the following test power supplies:

a. Direct-current generator
b. Battery
c. A polyphase rectifier power supply having more than six pulses per cycle and 15 percent or less phase control
d. Any of the power supplies listed in 12.66.2.2 provided sufficient series inductance is used to obtain 6 percent, or less, peak-to-peak armature current ripple.

12.66.2.2 Other Rectifier Power Supplies

The rating of direct-current motors intended for use on rectifier power supplies other than those described in 12.66.2.1 shall be based on the use of a test power supply having the characteristics given in 12.66.2.3 and defined in 12.66.2.4.

12.66.2.3 Power Supply Characteristics

12.66.2.3.1 Input

a. Single phase or three phase, as specified.
b. Specified frequency unless otherwise specified, the frequency shall be 60 hertz.
c. Specified alternating-current voltage, plus 2 percent, minus 0 percent.
d. Power source shall not introduce significant series impedance.

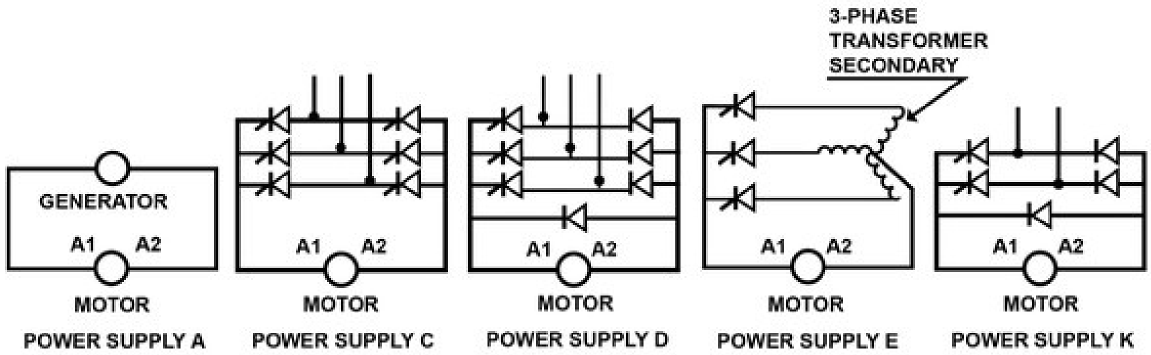

Figure 12-1
TEST POWER SUPPLIES

12.66.2.3.2 Output

a. Rated direct-current motor voltages.
b. Adequate direct current for all required tests.
c. The difference between the highest and lowest peak amplitudes of the current pulses over one. cycle shall not exceed 2 percent of the highest pulse amplitude.

12.66.2.4 Supplies Designated by a Single Letter

A test power supply designated by a single letter shall have all of the characteristics listed in 12.66.2.3 and in addition the following.

12.66.2.4.1 Power Supply C

Power supply identification letter "C" designates a three-phase full-wave power supply having six total pulses per cycle and six controlled pulses per cycle, without free wheeling, with 60 hertz input, with no series inductance being added externally to the motor armature circuit inductance. The input line-to-line alternating-current voltage to the rectifier shall be 230 volts for motor ratings given in Table 10-9 of 10.62 and 460 volts for motor ratings given in Table 10-10 of 10.62.

12.66.2.4.2 Power Supply D

Power supply identification letter "D" designates a three-phase semibridge having three controlled pulses per cycle, with freewheeling, with 60 hertz input, with no series inductance being added externally to the motor armature circuit inductance. The input line-to-line alternating-current voltage to the rectifier shall be 230 volts for motor ratings given in Table 10-9 of 10.62 and 460 volts for motor ratings given in Table 10-10 of 10.62.

12.66.2.4.3 Power Supply E

Power supply identification letter "E" designates a three-phase single-way power supply having three total pulses per cycle and three controlled pulses per cycles, without free wheeling, with 60 hertz input, and with no series inductance being added externally to the motor armature circuit inductance. The input line-to-line alternating-current voltage to the rectifier shall be 460 volts for motor ratings given in Table 10-10 of 10.62.

12.66.2.4.4 Power Supply K

Power supply identification letter "K" designates a single-phase full-wave power supply having two total pulses per cycle and two controlled pulses per cycle, with free wheeling, with 60 hertz input, with no series inductance being added externally to the motor armature circuit inductance. The input alternating-current voltage to the rectifier shall be 230 volts for motors with armature voltage ratings of 180 volts in Table 10-8 and 115 volts for motors with armature voltage ratings of 90 volts.

12.67 Temperature Rise

The temperature rise above the temperature of the cooling medium for each of the various parts of the motor when tested in accordance with the rating at base speed, shall not exceed the values given in the following tables.

12.67.1 Direct-Current Small Motors

All temperature rises in the following table are based on a maximum ambient temperature of 40°C. Temperatures measured by either the thermometer or resistance method shall be determined in accordance with IEEE Std 113.

Class of Insulation System (see 1.65)	**A**	**B**	**F***
Time Rating (shall be continuous or any short-time rating given in 10.36)			
Temperature Rise (based on a maximum ambient temperature of 40°C), Degrees C			
a. Armature windings and all windings other than those given in item b – resistance	70	100	130
b. Shunt field windings – resistance	70	100	130
c. The temperature attained by cores, commutators, and miscellaneous parts (such as brushholders, brushes, pole tips, etc.) shall not injure the insulation or the machine in any respect.			

NOTES:

1. Abnormal deterioration of insulation may be expected if the ambient temperature of 40°C is exceeded in regular operation see 12.67.4.
2. The foregoing values of temperature rise are based upon operation at altitudes of 3300 feet (1000 meters) or less. For temperature rises for motors intended for operation at altitudes above 3300 feet (1000 meters), see 14.4.

12.67.2 Continuous-Time-Rated Direct-Current Medium Motors

All temperature rises in the following table are based on a maximum ambient temperature of 40°C. Temperatures shall be determined in accordance with IEEE Std. 113.

	Totally Enclosed Nonventilated and Totally Enclosed Fan-Cooled Motors, Including Variations Thereof				**Motors with all Other Enclosures**			
Class of insulation system (see.1.65)	A	B	F	H	A	B	F	H
Time Rating	Continuous				Continuous			
Temperature rise, Degrees C								
a. Armature windings and all other than those given in items b and c - resistance	70	100	130	155	70	100	130	155
b. Multi-layer field windings – resistance	70	100	130	155	70	100	130	155
c. Single-layer field windings with exposed uninsulated surfaces and bare copper windings – resistance	70	100	130	155	70	100	130	155
d. The temperature attained by cores, commutators, and miscellaneous parts (such as brushholders, brushes, pole tips, etc.) shall not injure the insulation or the machine in any respect.								

NOTES:

1. Abnormal deterioration of insulation may be expected if the ambient temperature of 40°C is exceeded in regular operation. See 12.67.4.
2. The foregoing values of temperature rise are based upon operation at altitudes of 3300 feet (1000 meters) or less. For temperature rises for motors intended for operation at altitudes above 3300 feet (1000 meters), see 14.4.

12.67.3 Short-Time-Rated Direct-Current Medium Motors

All temperature rises in the following tables are based on a maximum ambient temperature of 40°C. Temperatures shall be determined in accordance with IEEE Std 113.

	Motors Rated 5 and 15 Minutes*							
	Totally Enclosed Nonventilated and Totally Enclosed Fan-Cooled Motors, Including Variations Thereof				**Dripproof, Forced-Ventilated** and Other Enclosures**			
Class of insulation system (see.1.65)	A	B	F	H	A	B	F	H
Temperature rise, Degrees C								
a. Armature windings and all other than those given in items b and c – resistance	90	125	155	185	80	115	145	175
b. Multi-layer field windings – resistance	90	125	155	155	80	115	145	175
c. Single-layer field windings with exposed uninsulated surfaces and bare copper windings – resistance	90	125	155	185	80	115	145	175
d. The temperature attained by cores, commutators, and miscellaneous parts (such as brushholders, brushes, pole tips, etc.) shall not injure the insulation or the machine in any respect.								

	Motors Rated 30 and 60 Minutes*							
	Totally Enclosed Nonventilated and Totally Enclosed Fan-Cooled Motors, Including Variations Thereof				Dripproof, Forced-Ventilated** and Other Enclosures			
Class of insulation system (see 1.65)	A	B	F	H	A	B	F	H
Temperature rise, Degrees C								
a. Armature windings and all other than those given in items b and c – resistance	80	110	140	165	70	100	130	155
b. Multi-layer field windings – resistance	80	110	140	165	70	100	130	155
c. Single-layer field windings with exposed uninsulated surfaces and bare copper windings – resistance	80	110	140	165	70	100	130	155
d. The temperature attained by cores, commutators, and miscellaneous parts (such as brushholders, brushes, pole tips, etc.) shall not injure the insulation or the machine in any respect.								

*See 10.63
**Forced-ventilated motors are defined in 1.25.6, 1.25.7, and 1.26.4.
NOTES:

1. Abnormal deterioration of insulation may be expected if the ambient temperature of 40°C is exceeded in regular operation. See 12.67.4.
2. The foregoing values of temperature rise are based upon operation at altitudes of 3300 feet (1000 meters) or less. For temperature rises for motors intended for operation at altitudes above 3300 feet (1000 meters), see 14.4.

12.67.4 Temperature Rise for Ambients Higher than 40°C

Temperature rises given in 12.67.1, 12.67.2, and 12.67.3 are based upon a reference ambient temperature of 40°C. However, it is recognized that dc machines may be required to operate in an ambient temperature higher than 40°C. For successful operation of dc machines in ambient temperatures higher than 40°C, the temperature rises of the machines given in 12.67.1, 12.67.2, and 12.67.3 shall be reduced by the number of degrees that the ambient temperature exceeds 40°C. When a higher ambient temperature than 40ºC is required, preferred values of ambient temperatures are 50°C, and 65°C.

12.67.5 Temperature Rise for Air-Cooled Machines for Ambients Lower than 40° C, but Not Below 0° C*

The temperature rises given in 12.67.1, 12.67.2, and 12.67.3 are based upon a reference ambient temperature of 40°C to cover most general environments. However, it is recognized that air-cooled dc machines may be operated in environments where the ambient temperature of the cooling air will always be less than 40°C. When an air-cooled dc machine is marked with a maximum ambient less than 40°C then the allowable temperature rises in 12.67.1, 12.67.2, and 12.67.3 shall be increased according to the following:

a. For machines for which the difference between the Reference Temperature and the sum of 40°C and the Temperature Rise Limit given in 12.67.1, 12.67.2, and 12.67.3 is less than or equal to 5°C then the temperature rises given in 12.67.1, 12.67.2, and 12.67.3 shall be increased by the amount of the difference between 40ºC and the lower marked ambient temperature.

b. For machines for which the difference between the Reference Temperature and the sum of 40°C and the Temperature Rise Limit given in 12.67.1, 12.67.2, and 12.67.3 is greater than 5°C, then the temperature rises given in 12.67.1, 12.67.2, and 12.67.3 shall be increased by the amount calculated from the following expression:

$$\text{Increase in Rise} = \{40°\text{C} - \text{Marked Ambient}\}\ \text{x}\ \left\{1 - \frac{\text{Reference Temperature} - (40°\text{C} + \text{Temperature Rise})}{80°\text{C}}\right\}$$

Where:

	Class of Insulation System			
	A	B	F	H
Reference Temperature, Degrees C	120	150	180	205

Temperature Rise Limit = Maximum allowable temperature rise according to 12.67.1, 12.67.2, and 12.67.3

*NOTE: This requirement does not include water-cooled machines.

For example: An open medium dc motor with a Class F insulation system is marked for use in an ambient with a maximum temperature of 25°C. From the Table above the Reference Temperature is 180ºC and from 12.67.2 the Temperature Rise Limit is 130°C. The allowable Increase in Rise to be added to the Temperature Rise Limit is then:

$$\{40°C - 25°C\}\ x\ \left\{1 - \frac{180°C - (40°C + 130°C)}{80°C}\right\} = 13°C$$

The total allowable Temperature Rise by Resistance above a maximum of a 25°C ambient is then equal to the sum of the Temperature Rise Limit from 12.67.2 and the calculated Increase in Rise. For this example, that total is 130°C + 13°C = 143°C.

12.68 Variation from Rated Voltage

Motors shall operate successfully, using the power supply selected for the basis of rating, up to and including 110 percent of rated direct-current armature and field voltages and, in the case of motors operating from a rectifier power supply, with a variation of plus or minus 10 percent of rated alternating-current line voltage. Performance within this voltage variation will not necessarily be in accordance with the standards established for operation at rated voltage. For operation below base speed, see 14.63.

12.69 Variation in Speed Due to Load

12.69.1 Straight-Shunt-Wound, Stabilized-Shunt-Wound, and Permanent-Magnet Direct-Current Motors

The variation in speed from rated load to no load of a straight-shunt-wound, stabilized-shunt-wound, or permanent-magnet direct-current motor having a rating listed in 10.62 shall not exceed the following when the motor is operated at rated armature voltage, with the winding at the constant temperature attained when operating at base speed rating, and the ambient temperature is within the usual service range given in 14.2.1, item a.

Hp	Speed Regulation, Percent (at Base Speed)
Less than 3	25
3-50	20
51-100	15
101 and larger	10

Variation in speed due to loads when operating at speeds higher than base speeds may be greater than the values in the above table.

12.69.2 Compound-Wound Direct-Current Motors

The variation in speed from rated load to no load of a compound-wound direct-current motor having a rating listed in 10.62 shall not exceed the values given in the following table for small motors and shall be approximately 30 percent of the rated load speed for medium motors when the motor is operated at rated voltage, with the windings at the constant temperature attained when operating at its rating, and the ambient temperature is within the usual service range given in 14.2.1, item a.

Hp	Speed, Rpm	Speed Regulation, Percent
1/20 to 1/8 incl.	1725	30
1/20 to 1/8, incl.	1140	35
1/6 to 1/3, incl.	1725	25
1/6 to 1/3, incl.	1140	30
1/2 to 3/4, incl.	1725	22
1/2	1140	25

12.70 Variation in Base Speed Due to Heating

12.70.1 Speed Variation with Temperature

The variation in base speed of straight-shunt-wound, stabilized-shunt-wound, and permanent magnet direct-current motors from that at rated load at ambient temperature to that at rated load at the temperature attained at rated load armature and field voltage following a run of the specified duration shall not exceed the following percentage of the rated base speed.

	Percentage Variation of Rated Load Base Speed			
	Insulation System Class			
Enclosure Type	A	B	F	H
Open	10	15	20	25
Totally Enclosed	15	20	25	30

12.70.2 Resistance Variation with Temperature

When the temperature of the motor winding changes from ambient temperature to that attained when the motor is operating at its rating, the resistance of the motor windings will increase approximately 30 percent for motors having Class A insulation systems, 40 percent for motors having Class B insulation systems, and 50 percent for motors having Class F insulation systems. With a constant voltage power supply, this will result in a speed change as large as that given in 12.70.1. Considering all factors, the speed of direct-current motors may either decrease or increase as the motor winding temperature increases. For small motors, the armature current form factor will also increase slightly with increasing motor winding temperature, but only with a single-phase rectifier is this likely to be significant.

12.71 Variation from Rated Speed

The variation above or below the rated full-field speed of a direct-current motor shall not exceed 7-1/2 percent when operated at rated load and voltage and at full field with the windings at the constant temperature attained when operating at its ratings.

12.72 Momentary Overload Capacity

Direct-current motors shall be capable of carrying successfully for 1 minute an armature current at least 50 percent greater than the rated armature current at rated voltage. For adjustable-speed motors, capability shall apply for all speeds within the rated speed range when operated from the intended power supply.

12.73 Successful Commutation

Successful commutation is attained if neither the brushes nor the commutator are burned or injured in the conformance test or in normal service to the extent that abnormal maintenance is required. The presence of some visible sparking is not necessarily evidence of unsuccessful commutation.

12.74 Overspeeds for Motors

12.74.1 Shunt-Wound Motors

Direct-current shunt-wound motors shall be so constructed that, in an emergency not to exceed 2 minutes, they will withstand without mechanical injury an overspeed of 25 percent above the highest rated speed or 15 percent above the corresponding no-load speed, whichever is greater.

12.74.2 Compound-Wound Motors Having Speed Regulation of 35 Percent or Less

Compound-wound motors shall be so constructed that, in an emergency not to exceed 2 minutes, they will withstand without mechanical injury an overspeed of 25 percent above the highest rated speed or 15 percent above the corresponding no-load speed, whichever is greater, but not exceeding 50 percent above the highest rated speed.

12.74.3 Series-Wound Motors and Compound-Wound Motors Having Speed Regulation Greater Than 35 Percent

Since these motors require special consideration depending upon the application for which they are intended, the manufacturer shall assign a maximum safe operating speed which shall be stamped on the nameplate. These motors shall be so constructed that in an emergency not to exceed 2 minutes, they will withstand without mechanical injury an overspeed which is 10 percent above the maximum safe operating speed. The safe operating speed marking is not required on the nameplates of small motors which are capable of withstanding a speed which is 10 percent above the no-load speed.

12.75 Field Data for Direct-Current Motors

See 12.81.

12.76 Routine Tests on Medium Direct-Current Motors

Typical tests which may be made on medium direct-current motors are listed below. All tests should be made in accordance with IEEE Std 113.

a. No-load readings[7] at rated voltage on all shunt-, stabilized-shunt, compound-wound, and permanent magnet motors; quarter-load readings[7] on all series-wound motors.
b. Full-load readings[7] at base and highest rated speed on all motors having a continuous torque rating greater than that of a 15-horsepower 1750-rpm motor. Commutation should be observed when full-load readings[7] are taken.
c. High-potential test in accordance with 3.1 and 12.3.

12.77 report of test form for direct-current machines

For typical test forms, see IEEE Std 113.

12.78 Efficiency

12.78.1 Type A Power Supplies

Efficiency and losses shall be determined in accordance with IEEE Std 113 using the direct measurement method or the segregated losses method. The efficiency shall be determined at rated output, voltage, and speed. In the case of adjustable-speed motors, the base speed shall be used unless otherwise specified.

The following losses shall be included in determining the efficiency:

a. I^2R loss of armature
b. I^2R loss of series windings (including commutating, compounding, and compensating fields, where applicable)
c. I^2R loss of shunt field[8]
d. Core loss
e. Stray load loss
f. Brush contact loss
g. Brush friction loss
h. Exciter loss if exciter is supplied with and driven from the shaft of the machine
i. Ventilating losses
j. Friction and windage loss[9]

[7] The word “readings” includes the following:

a. Speed in revolutions per minute
b. Voltage at motor terminals
c. Amperes in armature
d. Amperes in shunt field

[8] For separately excited motors, the shunt field I2R loss shall be permitted to be omitted from the efficiency calculation if so stated.

[9] In the case of motors furnished with thrust bearings, only that portion of the thrust bearing loss produced by the motor itself shall be included in the efficiency calculations. Alternatively, a calculated value of efficiency, including bearing loss due to external thrust load, shall be permitted to be specified.

In the case of motors furnished with less than a full set of bearings, friction and windage losses which are representative of the actual installation shall be determined by (1) calculation or (2) experience with shop test bearings and shall be included in the efficiency calculations.

In determining I^2R losses, the resistance of each winding shall be corrected to a temperature equal to an ambient temperature of 25°C plus the observed rated load temperature rise measured by resistance. When the rated load temperature rise has not been measured, the resistance of the winding shall be corrected to the following temperature:

Class of Insulation System	Temperature, Degrees C
A	85
B	110
F	135
H	155

If the temperature rise is specified as that of a lower class of insulation system, the temperature for resistance correction shall be that of the lower insulation class.

12.78.2 Other Power Supplies

It is not possible to make a simulated test which will determine motor efficiency in a particular rectifier system. Only by directly measuring input watts (not the product of average volts and average amperes) using the power supply to be used in an application can the motor efficiency in that system be accurately determined. The extra losses due to the ripple in the current, and especially those due to magnetic pulsations, are a function not only of the magnitude of the armature current ripple but, also, of the actual wave shape.

12.79 Stability

When motors are operated in feedback control systems, due attention should be paid to stability problems. Any such problems would necessarily have to be solved by the joint efforts of the system designer, the motor manufacturer, and the manufacturer of the power supply.

12.80 Over Temperature Protection of Medium Direct-Current Motors

Over-temperature protection of the various windings in a direct-current motor, especially the armature winding which rotates, is considerably more complex than the protection of the stator winding of an alternating-current motor. The wide range of load and speed (ventilation) in the typical direct-current motor application adds to the difficulty. Current-sensing devices located remotely from the motor (frequently in control panels) cannot match the thermal characteristics of direct-current motors over a wide speed range because of these variable motor cooling conditions.

In order to improve the degree of over-temperature protection, a temperature sensing protector may be installed in a direct-current motor. However, the precision of protection in over-temperature protected direct-current motors is less than that possible in alternating-current motors. In over temperature-protected direct-current motors, the protector is usually mounted on or near the commutating coil. Since this winding carries armature load current, its temperature tends to rise and fall with changes in load in a manner similar to the temperature of the armature winding.

The motor manufacturer should choose the protector and its mounting arrangement to prevent excessive temperatures of either the commutating field or the armature winding under most conditions of operation. However, under unusual loading conditions, the over-temperature protector may not be able to prevent the armature winding from reaching excessive temperatures for short periods. Maximum winding temperatures at operation of the over-temperature protector may exceed the rated temperature rise. Repeated operation of the over-temperature protector indicates a system installation which should be investigated.

If a direct-current motor is specified to be over-temperature protected, the user should inform the motor manufacturer whether a normally open or a normally closed contact device is required and the voltage, current, and frequency rating of the circuit which this device is intended to open or close.

12.81 Data for Direct-Current Motors

The following may be used in supplying data for direct-current motors:

a. Manufacturer's type	______________________
and frame designation	______________________
b. Requisition or order number	______________________
c. Rated horsepower	______________________
d. Time rating	______________________
e. Enclosure type	______________________
f. Insulation system	
g. Maximum ambient temperature	
h. Intended for use on power supply	
i. (Check one) Straight-shunt wound ( ), stabilized-shunt wound ( ), compound wound ( ), series wound ( ), or permanent magnet ( )	
j. Rated voltage	
1. Armature	_________volts, average
2. Shunt field	_________volts, average
k. Rated armature current	_________amperes, average
l. Rated form factor_____________or rms current____________amperes	
m. Resistance of windings at 25°	
1. Armature	__________ohms
2. Commutating (and compensating, if used)	__________ohms
3. Series	__________ohms
4. Shunt	__________ohms
n. Field amperes to obtain the following speeds at rated load amperes:	
1. Base speed	______rpm______amperes
2. 150 percent of base speed, if applicable	______rpm______amperes
3. Highest rated speed	______rpm______amperes
o. Saturated inductances	
1. Total armature circuit	______________millihenries
2. Highest rated speed	______________millihenries
p. Armature inertia (Wk^2)	__________lb-ft²
q. If separately ventilated, minimum cubic feet per minute and static pressure	____cfm_____inches of water
r. Maximum safe operating speed (for all series-wound and compound-wound motors having speed regulation greater than 35 percent)	__________rpm
s. Temperature protection data	

NOTE: For permanent-magnet motors and other motor designs, some of the above listed items may not be applicable. Other data may be given.

12.82 Machine Sound of Direct-Current Medium Motors

See Part 9 for Sound Power Limits and Measurement Procedures.

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