THE SCOPE OF COVERAGE FOR THE SMALL ELECTRIC MOTORS ENERGY CONSERVATION STANDARDS RULEMAKING

This document contains the exact definition from the statute for small electric motors, and then provides excerpts from the industry standard referenced in the statute (NEMA MG 1-1987).

STATUTORY DEFINITION

Section 340(13)(F) of EPCA (42 U.S.C. 6311(13)(F)) defines "small electric motor" using a dated standards publication from the National Electrical Manufacturers Association (NEMA):

> *"(F) The term "small electric motor" means a NEMA general purpose alternating current single-speed induction motor, built in a two-digit frame number series in accordance with NEMA Standards Publication MG 1-1987."*

NEMA MG 1-1987 DEFINITIONS

Part 1 of NEMA MG 1-1987 presents definitions for various terms used in the statutory definition of "small electric motor." This section presents these relevant definitions.

D.1. General Purpose

NEMA defines **general-purpose alternating-current motor** in section MG 1-1.05 as follows:

"MG 1-1.05 GENERAL-PURPOSE ALTERNATING-CURRENT MOTOR

A general-purpose alternating-current motor is an induction motor, rated 200 horsepower and less, which incorporates all of the following:

1. Open construction.
2. Rated continuous duty.
3. Service factor in accordance with MG 1-12.47.
4. Class A insulation system with a temperature rise as specified in MG 1-12.42 for small motors or Class B insulation system with a temperature rise as specified in MG 1-12.43 for medium motors.

It is designed in standard ratings with standard operating characteristics and mechanical construction for use under usual service conditions without restriction to a particular application or type of application."

As referenced in the definition of general-purpose alternating-current motor, an **open machine** is defined in section MG 1-1.25 by the term as follows:

"MG 1-1.25 OPEN MACHINE

An open machine is one having ventilating openings which permit passage of external cooling air over and around the windings of the machine. The term 'open machine,' when applied to large apparatus without qualification, designates a machine having no restriction to ventilation other than that necessitated by mechanical construction."

As referenced in the definition of general-purpose alternating-current motor, **MG 1-12.47** states that the service factor must be in accordance with Table 12-2 shown below:

Table 12-2

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

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

As referenced in the definition of general-purpose alternating-current motor, a **small machine** is defined in section MG 1-1.02 as follows:

"MG 1-1.02 SMALL (FRACTIONAL) MACHINE

A small machine is either (1) a machine built in a two-digit frame number series in accordance with 11.01.1 or (2) a machine built in a frame smaller than that frame of a medium machine (see MG 1-1.03) which has a continuous, open-construction rating at 1700-1800 rpm of 1 horsepower for motors or 0.75 kilowatt for generators."

As referenced in the definition of general-purpose alternating-current motor, **MG 1-12.42** states that the temperature rise of small motors shall not exceed the values given in the following table:

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

(See following page for notes.)

D.2. Single-Speed

NEMA MG 1-1987 does not define the term **single-speed**.

D.3. Induction Motor

NEMA classifies and defines **induction motor** in section 1.15.1 as follows:

"1.15.1 INDUCTION MOTOR

An induction motor is an induction machine in which a primary winding on one member (usually the stator) is connected to the power source and a polyphase secondary winding or a squirrel-cage secondary winding on the other member (usually the rotor) carries induced current.

1.15.1.1 SQUIRREL-CAGE INDUCTION MOTOR

A squirrel-cage induction motor is an induction motor in which the secondary circuits (squirrel-cage winding) consists of a number of conducting bards having their extremities connected by metal rings or plates at each end.

1.15.1.2 WOUND-ROTOR INDUCTION MOTOR

A wound-rotor induction motor is an induction motor in which the secondary circuit consists of a polyphase winding or coils whose terminals are either short-circuited or closed through suitable circuits."

NEMA classifies and defines **single-phase squirrel-cage induction motors** in section 1.17.3 as follows:

"1.17.3.1 SPLIT-PHASE MOTOR

A split-phase motor is a single-phase induction motor equipped with an auxiliary winding displaced in magnetic position from, and connected in parallel with, the main winding.

Unless otherwise specified, the auxiliary circuit is assumed to be opened when the motor has attained a predetermined speed. The term "split-phase motor," used without qualification, describes a motor to be used without impedance other than that offered by the motor windings themselves, other types being separately defined.

1.17.3.2 RESISTANCE-START MOTOR

A resistance-start motor is a form of split-phase motor having a resistance connected in series with the auxiliary winding. The auxiliary circuit is opened when the motor has attained a predetermined speed.

1.17.3.3 CAPACITOR MOTOR

A capacitor motor is a single-phase induction motor with a main winding arranged for direct connection to a source of power and an auxiliary winding connected in series with a capacitor. There are three types of capacitor motors, as follows:

1.17.3.3.1 CAPACITOR-START MOTOR

A capacitor-start motor is a capacitor motor in which the capacitor phase is in the circuit only during the starting period.

1.17.3.3.2 PERMANENT-SPLIT CAPACITOR MOTOR

A permanent-split capacitor motor is a capacitor motor having the same value of capacitance for both starting and running conditions.

1.17.3.3.3 TWO-VALUE CAPACITOR MOTOR

A two-value capacitor motor is a capacitor motor using different values of effective capacitance for the starting and running conditions.

1.17.3.4 SHADED-POLE MOTOR

A shaded-pole motor is a single-phase induction motor provided with an auxiliary short-circuited winding or windings displaced in magnetic position from the main winding."

NEMA classifies and defines **single-phase wound-rotor induction motors** in section 1.17.4 as follows:

"1.17.4.1 REPULSION MOTOR

A repulsion motor is a single-phase motor which has a stator winding arranged for connection to a source of power and a rotor winding connected to a commutator. Brushes on the commutator are short-circuited and are so placed that the magnetic axis of the rotor winding is inclined to the magnetic axis of the stator winding. This type of motor has a varying-speed characteristic.

1.17.4.2 REPULSION-START INDUCTION MOTOR

A repulsion-start induction motor is a single phase motor having the same windings as a repulsion motor, but at a predetermined speed the rotor winding is short circuited or otherwise connected to give the equivalent of a squirrel-cage winding. This type of motor starts as a repulsion motor but operates as an induction motor with constant-speed characteristics.

1.17.4.3 REPULSION-INDUCTION MOTOR

A repulsion-induction motor is a form of repulsion motor which has a squirrel-cage winding in the rotor in addition to the repulsion motor winding. A motor of this type may have either a constant speed (see MG 1-1.30) or varying-speed (see MG 1-1.31) characteristic."

D.4. Two-Digit Frame Number Series

Section 1-11.01.1 defines the system for designating frame sizes for small machines (as defined by NEMA MG 1-1987). Small machines, as defined in section MG 1-1.02, encompass all machines built in a two-digit frame number series. The two-digit frame number is defined as follows:

"The frame number for small machines shall be the D dimension in inches multiplied by 16"

Section MG 1-4.01 defines the D dimension as the "centerline of shaft to bottom of feet" dimension. The equivalent IEC letter is denoted as "H".

NEMA MG 1-1987 STANDARDS

Later parts of NEMA MG 1-1987 include standards and rating for various motors meeting the above discussed definitions. The following section discusses these standards as they relate to scope of coverage for small electric motors. The MG-1 standards discussed in the following section are not explicitly referenced by the definitions of any of the terms listed above.

S.1. Horsepower Ratings

Section 10.32.1 states that the horsepower and speed ratings for small induction motors, except permanent-split capacitor motors rated 1/3 horsepower and smaller and shaded-pole motors shall be[1] as shown in Table 10-1. Section 10.32.2 states that ratings for small permanent-split capacitor motors rated 1/3 horsepower and smaller and small shaded-pole motors shall be as shown in Table 10-2. As seen in the tables below, MG 1-1987 identifies small induction motors as motors with horsepower ratings from 1 millihorsepower up to 1 horsepower.

Table 10-1
Horsepower and Speed Ratings, Small Induction Motors

	All Motors Except Shaded-Pole and Permanent-split Capacitor		Permanent-split Capacitor Motors	All Motors Except Shaded-Pole and Permanent-split Capacitor		Permanent-split Capacitor Motors
Hp	60-hertz Synchronous Rpm	Approximate Rpm at Rated Load		50-hertz Synchronous Rpm	Approximate Rpm at Rated Load	
1, 1.5, 2, 3, 5, 7.5, 10, 15, 25, and 35 millihorsepower	3600	3450	. . .	3000	2850	. . .
	1800	1725	. . .	1500	1425	. . .
	1200	1140	. . .	1000	950	. . .
	900	. . .	. . .			
1/20, 1/12, and 1/8 horsepower	3600	3450	. . .	3000	2850	. . .
	1800	1725	. . .	1500	1425	. . .
	1200	1140	. . .	1000	950	. . .
	900	850	. . .			
1/6, 1/4, and 1/3 horsepower	3600	3450	. . .	3000	2850	. . .
	1800	1725	. . .	1500	1425	. . .
	1200	1140	. . .	1000	950	. . .
	900	850	. . .			
1/2 horsepower	3600	3450	3250	3000	2850	2700
	1800	1725	1625	1500	1425	1350
	1200	1140	1075	1000	950	900
3/4 horsepower	3600	3450	3250	3000	2850	2700
	1800	1725	1625	1500	1425	1350
1 horsepower	3600	3450	3250	3000	2850	2700

[1] *In NEMA MG 1-2006, the table represents "typical" horsepower and speed ratings, rather than mandating that horsepowers and speed ratings "shall be" as shown in the table.*

Table 10-2
Horsepower and Speed Ratings, Permanent-Split Capacitor and Shaded Pole Motors

Permanent-split Capacitor Motors

Hp	60-Hertz Synchronous Rpm	Approximate Rpm at Rated Load	50-Hertz Synchronous Rpm	Approximate Rpm at Rated Load
1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12.5, 16, 20, 25, 30, and 40 milli-horsepower	3600 1800 1200 900	3000 1550 1050 800	3000 1500 1000	2500 1300 875
1/20, 1/15, 1/12, 1/10, 1/8, 1/6, 1/5, 1/4, and 1/3 horsepower	3600 1800 1200 900	3250 1625 1075 825	3000 1500 1000	2700 1350 900

Shaded-pole Motors

Hp	60-Hertz Synchronous Rpm	Approximate Rpm at Rated Load	50-Hertz Synchronous Rpm	Approximate Rpm at Rated Load
1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12.5, 16, 20, 25, 30, and 40 millihorse-power	1800 1200 900	1550 1050 800	1500 1000	1300 875
1/20, 1/15, 1/12, 1/10, 1/8, 1/6, 1/5, and 1/4 horsepower	1800 1200 900	1550 1050 800	1500 1000	1300 875

S.2. Standard Frame Sizes

Part 11 of MG 1-1987 identifies three standard two-digit frame size, 42, 48, and 56.

S.3. Locked-Rotor Torque and Current Ratings

Section 12.32.2 states that the locked-rotor torque of single-phase general-purpose small motors shall be not less than the values indicated in the table to the left below. Section 12.33.1 states that the locked-rotor current of single-phase general-purpose small motors shall not exceed the values (Design N) indicated in the table to the right below.

	Minimum Locked-rotor Torque, Ounce-feet*					
	60-Hertz Synchronous Speed, Rpm			50-Hertz Synchronous Speed, Rpm		
Hp	3600 3450	1800 1725	1200 1140	3000 2850	1500 1425	1000 950
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	. . .	. . .

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

2-, 4-, 6-, and 8-Pole, 60-Hertz Motors, Single Phase				
	Locked-rotor Current, Amperes			
	115 Volts		230 Volts	
Hp	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 The locked-rotor currents of single-phase general-purpose motors shall not exceed the values for Design N motors.

NEMA Standard 10-29-1943, revised 11-14-1957; 5-21-1962; 11-12-1964; 11-21-1968.

S.4. Breakdown Torque Ratings

Section 12.32.1 states that the breakdown torque of a general-purpose single-phase small induction motor shall be higher than the figure in each torque range as given by Table 10-5. Section MG 1-10.34 states that the breakdown torque to be expected by the user for any horsepower and speed shall fall within the ranges given in Tables 10-5 and 10-6. As seen in the tables below the breakdown torques of many shaded-pole and permanent-split capacitor motors do not fall in the breakdown torque ranges of Table 10-5.

Table 10-5*† ▲

INDUCTION MOTORS, EXCEPT SHADED-POLE AND PERMANENT-SPLIT CAPACITOR MOTORS

60	50	60	50	60	50	60	50		Frequencies, hertz
3600	3000	1800	1500	1200	1000	900	750		Synchronous Speeds, Rpm
3450††	2850††	1725††	1425†	1140††	950††	850††	...	Hp	Small Motors, Nominal Speeds, Rpm
								Millihp	
0.35-0.55	0.42-0.66	0.7-1.1	0.85-1.3	1.1-1.65	...	...	...	1	The figures at left are for motors rated less than 1/20 horsepower. Breakdown torques in oz-in.
0.55-0.7	0.66-0.85	1.1-1.45	1.3-1.75	1.65-2.2	...	...	...	1.5	
0.7-1.1	0.85-1.3	1.45-2.2	1.75-2.6	2.2-3.3	...	...	...	2	
1.1-1.8	1.3-2.2	2.2-3.6	2.6-4.3	3.3-5.4	...	...	...	3	
1.8-2.7	2.2-3.2	3.6-5.4	4.3-6.6	5.4-8.1	...	...	...	5	
2.7-3.6	3.2-4.3	5.4-7.2	6.6-8.6	8.1-11	...	...	...	7.5	
3.6-5.5	4.3-6.6	7.2-11	8.6-13	11-17	...	...	...	10	
5.5-9.5	6.6-11.4	11-19	13-23	17-29	...	...	...	15	
9.5-15	11.4-18	19-30	23-36	29-46	...	...	...	25	
15-24	18-28.8	30-48	36-57.6	46-72	...	...	...	35	
								Hp	
2.0-3.7	2.4-4.4	4.0-7.1	4.8-8.5	6.0-10.4	7.2-12.4	8.0-13.5	...	1/20	The figures at left are for small motors. Breakdown torques in oz-ft.
3.7-6.0	4.4-7.2	7.1-11.5	8.5-13.8	10.4-16.5	12.4-19.8	13.5-21.5	...	1/12	
6.0-8.7	7.2-10.5	11.5-16.5	13.8-19.8	16.5-24.1	19.8-28.9	21.5-31.5	...	1/8	
8.7-11.5	10.5-13.8	16.5-21.5	19.8-25.8	24.1-31.5	28.9-37.8	31.5-40.5	...	1/6	
11.5-16.5	13.8-19.8	21.5-31.5	25.8-37.8	31.5-44.0	37.8-53.0	40.5-58.0	...	1/4	
16.5-21.5	19.8-25.8	31.5-40.5	37.8-48.5	44.0-58.0	53.0-69.5	58.0-77.0	...	1/3	
21.5-31.5	25.8-37.8	40.5-58.0	48.5-69.5	58.0-82.5	69.5-99.0				
31.5-44.0	37.8-53.0	58.0-82.5	69.5-99.0			**	**	1/2	
44.0-58.0	53.0-69.5			5.16-6.9	**	**	**	3/4	The figures at left are for medium motors. Breakdown torques in lb-ft.
		5.16-6.8	6.19-8.2	6.9-9.2	**	**	**	1	
3.6-4.6	4.3-5.5	6.8-10.1	8.2-12.1	9.2-13.8	**	**	**	1 1/2	
4.6-6.0	5.5-7.2	10.1-13.0	12.1-15.6	13.8-18.0	**	**	**	2	
6.0-8.6	7.2-10.2	13.0-19.0	15.6-22.8	18.0-25.8	**	**	**	3	
8.6-13.5	10.2-16.2	19.0-30.0	22.8-36.0	25.8-40.5	**	**	**	5	
13.5-20.0	16.2-24.0	30.0-45.0	36.0-54.0	40.5-60.0	**	**	**	7 1/2	
20.0-27.0	24.0-32.4	45.0-60.0	54.0-72.0	**	**	**	**	10	

*The breakdown torque range includes the higher figure down to, but not including, the lower figure.

†The horsepower rating of motors designed to operate on two or more frequencies shall be determined by the torque at the highest rated frequency.

††These approximate full-load speeds apply only for small motor ratings.

**These are ratings for which no torque values have been established.

Table 10-6*†
SHADED-POLE AND PERMANENT-SPLIT CAPACITOR MOTORS FOR FAN AND PUMP APPLICATIONS
(For permanent-split capacitor hermetic motors, see MG 1-18.081.)

60	50	60	50	60		Frequencies, hertz
1800	1500	1200	1000	900		Synchronous Speeds, Rpm
See 10.32.1 and 10.32.2					Hp	Approximate Full-load Speeds, Rpm
					Millihp	
0.89–1.1	1.1–1.3	1.3–1.6	1.6–1.9	1.7–2.1	1	
1.1–1.4	1.3–1.7	1.6–2.1	1.9–2.5	2.1–2.7	1.25	
1.4–1.7	1.7–2.0	2.1–2.5	2.5–3.0	2.7–3.3	1.5	
1.7–2.1	2.0–2.5	2.5–3.1	3.0–3.7	3.3–4.1	2	
2.1–2.6	2.5–3.1	3.1–3.8	3.7–4.6	4.1–5.0	2.5	
2.6–3.2	3.1–3.8	3.8–4.7	4.6–5.7	5.0–6.2	3	
3.2–4.0	3.8–4.8	4.7–5.9	5.7–7.1	6.2–7.8	4	
4.0–4.9	4.8–5.8	5.9–7.2	7.1–8.7	7.8–9.5	5	The figures at left are breakdown torques in oz-in.
4.9–6.2	5.8–7.4	7.2–9.2	8.7–11.0	9.5–12.0	6	
6.2–7.7	7.4–9.2	9.2–11.4	11.0–13.6	12.0–14.9	8	
7.7–9.6	9.2–11.4	11.4–14.2	13.6–17.0	14.9–18.6	10	
9.6–12.3	11.4–14.7	14.2–18.2	17.0–21.8	18.6–23.8	12.5	
12.3–15.3	14.7–18.2	18.2–22.6	21.8–27.1	23.8–29.6	16	
15.3–19.1	18.2–22.8	22.6–28.2	27.1–33.8	29.6–37.0	20	
19.1–23.9	22.8–28.5	28.2–35.3	33.8–42.3	37.0–46.3	25	
23.9–30.4	28.5–36.3	35.3–44.9	42.3–53.9	46.3–58.9	30	
30.4–38.3	36.3–45.6	44.9–56.4	53.9–68.4	58.9–74.4	40	
					Hp	
3.20–4.13	3.80–4.92	4.70–6.09	5.70–7.31	6.20–8.00	1/20	
4.13–5.23	4.92–6.23	6.09–7.72	7.31–9.26	8.00–10.1	1/15	
5.23–6.39	6.23–7.61	7.72–9.42	9.26–11.3	10.1–12.4	1/12	The figures at left are breakdown torques in oz-ft.
6.39–8.00	7.61–9.54	9.42–11.8	11.3–14.2	12.4–15.5	1/10	
8.00–10.4	9.54–12.4	11.8–15.3	14.2–18.4	15.5–20.1	1/8	
10.4–12.7	12.4–15.1	15.3–18.8	18.4–22.5	20.1–24.6	1/6	
12.7–16.0	15.1–19.1	18.8–23.6	22.5–28.3	24.6–31.0	1/5	
16.0–21.0	19.1–25.4	23.6–31.5	28.3–37.6	31.0–41.0	1/4	
21.0–31.5	25.4–37.7	31.5–47.0	37.6–56.5	41.0–61.0	1/3	
31.5–47.5	37.7–57.3	47.0–70.8	56.5–84.8	3.81–5.81	1/2	
47.5–63.5	57.3–76.5	4.42–5.88	5.30–7.06	5.81–7.62	3/4	The figures at left are breakdown torques in lb-ft.
3.97–5.94	4.78–7.06	5.88–8.88	7.06–10.6	7.62–11.6	1	
5.94–7.88	7.06–9.56	8.88–11.8	10.6–14.1	11.6–15.2	1 1/2	

*The breakdown torque range includes the higher figure down to, but not including, the lower figure.
†The horsepower rating of motors designed to operate on two or more frequencies shall be determined by the torque at the highest rated frequency.