Motor nameplate: What information it provides

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The nameplate of an electric motor reveals much valuable information about the capability and performance of the machine. NEMA MG1-2014 (National Electrical Manufacturers Association Motors and Generators 1) and IEC 60034-8 (International Electrotechnical Commission) provide information required to be included on the plate to conform to the standards.

This varies by the type and size of the motor. For instance, rated field and armature voltages are required for direct current (DC) motors but obviously are not required for alternating current (AC) motors. **Table 1** lists the basic requirements applicable to motors. Not all motors will comply with these requirements. These include motors built before the implementation of the standards or outside the jurisdiction of the standards agencies. Some motors, such as synchronous and wound rotor motors, will have additional requirements. To cover all these is beyond the scope of this article. Here we will discuss the basic information. **Figures 1 and 2** are generic metal nameplates available to purchase from EASA to replace damaged or altered originals. The same data requirements exist for these replacements.

Identification

The manufacturer's information such as name, type and frame should be included. The manufacturer's name and type are determined by the manufacturer. Each may have unique type designations that identify a family of motor applications and specifications. The frame designation is standardized by NEMA through 449 frame. The frame can be identified by dividing the first two digits by four to get the shaft height ("D" dimension, center of shaft to bottom of foot); for example 44/4 = 11 inches. These are commonly referred to as "NEMA frames." For motors larger than this, referred to as "above NEMA," manufacturers can develop their own frame designations. Consequently, the same apparent frame number from different manufacturers may not have the same frame dimensions.

IEC 60072-1 defines the frame designations for metric motors. The frame designation is the shaft height in millimeters-of-foot mounted motors, ranging from 56 to 400 mm. For flange mounted motors, the bolt circle hole ranges from 55 to 1080 mm.

Table 1. Nameplate requirements.

Required Nameplate Markings	AC		DC	
	NEMA	IEC	NEMA	IEC
Manufacturer's Name	X	X	X	X
Manufacturer's Type	X	X	X	X
Manufacturer's Frame	X		X	
Power Output	X	X	X	X
Time Rating	X	X	X	X
Maximum Ambient	X	X	X	X
Insulation System	X	X	X	X
RPM at Rated load	X	X	X	X
Frequency	X	X		
Number of Phases	X	X		
Rated Load Amps	X	X		
Voltage	X	X		
Locked Rotor Amps	X			
Design Letter	X			
Efficiency	X	X		
Service Factor	X			
Rated Field Voltage			X	X
Rated Field Current				X
Rated Armature Voltage			X	
Rated Armature Current			X	
Winding Type			X	
Direct Current or DC			X	
Maximum Safe rpm		X	X	X
Manufacturer's ID Number		X		X
Year of Manufacture		X		X
Pertinent Standard		X		X
Degree of Protection		X		X
Power Factor		X		
Altitude		X		X
Connection		X		X

Power

Power output is the power level in horsepower (hp) or kilowatts (kW) for which the motor design is optimized. The motor will respond to the load connected to the shaft and try to provide the necessary torque. At this load point, the motor current will be the rated load amps on the nameplate. The rated current will be within ±10% for NEMA motors while no tolerance is found in IEC. If the load is less than the rated value, the motor load current will decrease.

This will have little impact on performance if the load is above 75% of the rated load; less than this and

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the efficiency and power factor will be reduced and the cost of operation will be negatively affected. If the load requires more power, the load current will increase, while also increasing the heating of the motor and thus reducing its life. If the motor has limits on the amount of time it can remain at full load, this will be designated in the time rating or duty cycle.

Maximum ambient

Maximum ambient is the maximum environmental (room) temperature that the temperature rise produced by the motor will allow to remain within the insulation class. The insulation system is classed by the letters A, B, F and H. The total winding temperature is shown in **Table 2** and, based on the ambient, the temperature rise contribution of the motor is listed. This table is a simplification. Temperature rise will vary based on motor size and enclosure. See the November 2003 *Currents* article titled "Understanding motor temperature limits" for additional detail.

Classes A and B are not used in the motor manufacturing process any longer, but occasionally a motor with Class F insulation will be designed for Class B rise. This conservative approach ensures the motor will operate at a cooler temperature and will have an extended service life. If the motor is to operate in an ambient of greater temperature, the design will have less allowable temperature rise.

Speed

Rated revolutions per minute (rpm) and frequency are directly related. The

Table 2. Temperature classes in degrees Celsius.

Temperature Class		Allowable rise w/ 40º C ambient
A	105	65
B	130	90
F	155	115
H	180	140

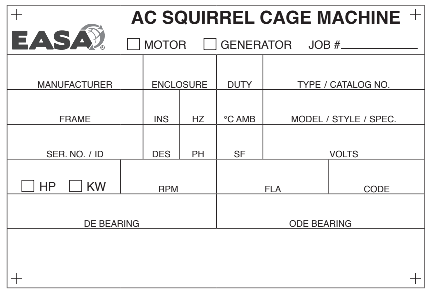

Figure 1. AC nameplate.

synchronous speed of a motor can be determined by the formula:

$$\frac{\text{Frequency x 2 x 60 seconds/minute}}{\text{Number of poles}} = \text{rpm}$$

As load is increased on a squirrel cage induction motor (SCIM), speed will be reduced. This is referred to as slip. The nameplate speed should be within ±20% of the actual slip for both NEMA and IEC motors. The rated speed of a SCIM or rated speed of a DC motor is the speed of the motor at rated load. Make special note here that the speed of a DC motor is not determined by the number of poles. The armature and field winding designs will define the rated speed of the DC motor.

Phase and voltage

Single-phase and 3-phase motors are the most common. There are some 2-phase motors still in operation, and there are special 6-phase motors. These are rare and should they come up, refer to EASA's technical support staff with your questions.

Voltage determines the power supply requirements to operate the motor. The motor must be capable of operating at ±10% (NEMA) or ±5% (IEC) of rated voltage and deliver the rated power output. See the February 2014 *Currents* article titled "The Impact of Voltage Variation on Motor Performance," which explains the pitfalls of this concept. As stated earlier, a lower voltage will require higher current to do the same work resulting in increased temperature and shortened life.

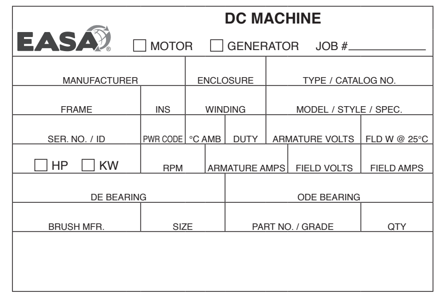

Figure 2. DC nameplate.

Code letter

The locked rotor amps (LRA) may be included on the nameplate, but often a NEMA code letter is used. IEC uses the approach of limiting the locked rotor apparent power based on a series of design letters in 60034-12. LRA may also be referred to as starting current or inrush current. **Table 3** provides the information to determine a range of LRA to expect for a given code letter. By using the formula provided with each of the kVA/hp values shown, the upper and lower limits of LRA can be determined. This range will accommodate manufacturing variations within the same motor design and allow for the proper selection of the motor controls.

Design letter

The NEMA design letter defines the profile of the torque developed as the motor accelerates to full speed as shown in **Figure 3**. Design B is used for the majority of applications. Designs C and D have much higher starting torques for applications that require it. Design A is a motor with a similar profile as Design B but does not meet the inrush current limits published in NEMA MG1. The primary factor in developing the different design profiles is the rotor cage. Therefore, the stator winding cannot be redesigned to change the design letter of a motor.

IEC design letters are N, NY, H and HY. Torque characteristics, locked rotor apparent power and starting requirements are listed in 60034-12.

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No direct relationship with locked rotor amps is given. **Figure 3** shows that Design N has a similar profile as NEMA Designs A and B, and Design H is similar to NEMA Design C. The NY and HY designs designate that the motors are suitable for wye start-delta run applications.

Efficiency and service factor

Efficiency has been an important factor in motor purchase decisions for many years. It is the ratio of the output power to the input power. The difference is referred to as motor losses, most of which produce useless heat rather than the work required to drive the load. The lower the losses that a design can produce, the higher its efficiency. This translates to lower utility operating costs.

Service factor is a multiplier that defines the load point at which a motor can operate thermally. Although there is no time limit in the definition, operating continually at the service factor load will significantly increase the operating temperature and shorten the expected life. Operating at a 1.15 service factor has been shown to increase the temperature as much as 30º C; and for each 10º C, the life expectancy is reduced by one-half. In this case, operating continuously at service factor would reduce the life of the motor to one-eighth of that at full load.

"IEC 60034-1 Section 4 defines ten different duty types. These combine elements of NEMA's duty cycle and service factor. S1 is continuous running duty at rated voltage, frequency and load. S2 through S10 describe various short-time or periodic-duty cycles. These are to be defined by the purchaser so that the motor can be designed accordingly."

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DC motors

DC motors have additional requirements for field and armature current and rated volts. When these conditions are met, the motor will operate at rated speed. If the field voltage is reduced (field weakening), the motor will accelerate. The maximum safe speed is the mechanical limit of the speed that is safe to operate the motor. This speed can also be limited by potential field instability. The motor should be identified by DC and the winding type. These types are shunt, series or compound or stabilized shunt.

Shunt motors have field windings that are parallel to the armature. In series motors, the fields are in series with the armature. Compound windings combine both to take advantage of the good speed control of the shunt and high torque throughout the speed range of the series motors. The percent of compounding is determined by the ratio of the series field ampere-turns over the total (shunt + series) ampere-turns. If this is less than 20%, it is called a stabilized shunt. For more information about DC nameplates, especially the field current, see the July 2002 *Currents* article titled "(Correctly) interpreting the DC nameplate."

IEC has additional requirements for both AC and DC machines. The manufacturer's identification number and year of manufacture should be on the nameplate. The pertinent standard is the IEC standard that applies to the

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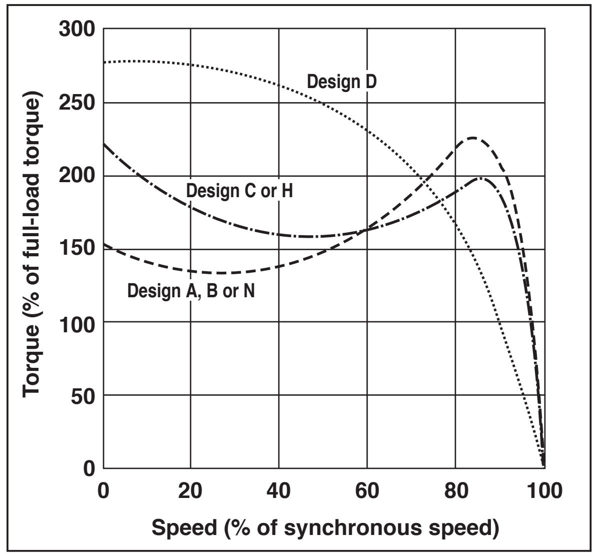

Figure 3. Typical speed torque curves.

Table 3. Locked rotor amps.

LETTER DESIGNATION	KVA PER HORSEPOWER*	LETTER DESIGNATION	KVA PER HORSEPOWER*
A	0 - 3.15	K	8.0 - 9.0
B	3.15 - 3.55	L	9.0 - 10.0
C	3.55 - 4.0	M	10.0 - 11.2
D	4.0 - 4.5	N	11.2 - 12.5
E	4.5 - 5.0	P	12.5 - 14.0
F	5.0 - 5.6	R	14.0 - 16.0
G	5.6 - 6.3	S	16.0 - 18.0
H	6.3 - 7.1	T	18.0 - 20.0
J	7.1 - 8.0	U	20.0 - 22.4
		V	22.4 - & up

* Locked kVA per horsepower range includes the lower figure up to, but not including, the higher figure. For example, 3.14 is designated by letter A and 3.15 by letter B. There are no code letters for IEC motors. To calculate the starting kVA per horsepower, use the equations below.

Reference: NEMA Stds. MG 1-2011, 10.37.2.

LOCKED-ROTOR AMPS FOR AC MOTORS

$$\text{Locked-rotor amps} = \frac{\text{Starting kVA/hp} \times \text{hp} \times 1000}{\text{Volts} \times (1 \text{ for } 1Ø \textit{ or } 1.732 \text{ for } 3Ø)}$$

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motor; often this is IEC 60034-x or 60079-x.

The IEC degree of protection has also been adopted by NEMA, but NEMA does not require it on the nameplate. This is a two-digit code following 'IP' that defines the level of protection for contaminates entering the motor. For instance, IP54 from **Table 4** is a dust- and splashing-water protected machine. For more information, see the December 2017 *Currents* article titled "Electrical machine enclosures: Degree of protection (IP) codes."

Power factor

Power factor is the ratio of the true power to the apparent power. Because a motor is a large inductive load, the voltage and current are out of phase. The apparent power is the voltage times the current that must be delivered to the motor in order for the true power to be accomplished. This is represented by the vector diagram in **Figure 4**.

The utility must provide the apparent power, but the true power is the watts for which the customer pays. Utilities often have a power factor demand charge to compensate for this. The power factor can be corrected by installing capacitors which have the opposite effect of the inductance of the motor.

Table 4. Degrees of protection.

First characteristic numeral	Degree of protection	Second characteristic numeral	Degree of protection
0	Non-protected machine	0	Non-protected machine
1	Machine protected against solid objects greater than 2 in (50 mm)	1	Machine protected against dripping water
2	Machine protected against solid objects greater than 0.5 in (12 mm)	2	Machine protected against dripping water when tilted up to 15°
3	Machine protected against solid objects greater than 0.1 in (2.5 mm)	3	Machine protected against spraying water
4	Machine protected against solid objects greater than 0.04 in (1 mm)	4	Machine protected against splashing water
5	Dust-protected machine	5	Machine protected against water jets
6†	Dust-tight machine	6	Machine protected against heavy seas
		7	Machine protected against the effects of immersion
		8	Machine protected against continuous submersion

† Not included in IEC Std. 60034-5.

References: NEMA Stds. MG 1, Part 5; and IEC Std. 60034-5.

Altitude

Altitudes above 1000 meters (3300 feet) reduce the cooling effect of the motor. The altitude on the nameplate is the maximum at which the motor will receive sufficient cooling at rated load. An oft-overlooked caution here is for repairers with customers at higher altitudes. It is not uncommon to see a motor with the nameplate horsepower downsized for operation at a high elevation, in which case a manufacturer will / should adjust the kilovolt ampere code to a higher letter to reflect the inrush current of the actual power rating.

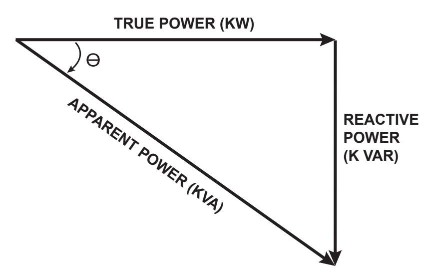

Figure 4. Power triangle.

Conclusion

Table 1 has the requirements for IEC and NEMA for AC and DC nameplates. As mentioned before, there are other specifications for specific motor designs. These requirements do not limit what can be included on the nameplate. For instance, many manufacturers include bearing nomenclature. This allows the user to acquire the correct bearings before removing the motor from service to reduce downtime. The nameplate is well worth a close examination, and a photograph can be of great value in the future. ●

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