INTRODUCTION:

Baldor Electric Company has prepared this Specifiers Guide to help you cover all the bases when you are specifying electric motors. It will cover in a generic way most of the subjects which you should consider when writing a specification for an electric motor. Additional specification material is available from the National Electric Manufacturers Association. Standard MG-1, and the National Electric Code.

The motor-application engineer matches operating characteristics and load requirements of an application with motor characteristics to provide dependable, economic service at minimum cost. For high-volume applications, extensive testing is practical to select the motor best suited for an application by taking advantage of special electrical or mechanical designs. However, in many applications, because of volume, cost, or expediency, it is desirable to use motors that are available from the manufacturers' stock. These motors are generally called standard, stock, or catalog motors.

We will discuss common industrial applications with guides for the proper use of electric motors on these.

For the convenience of the motor buyer or specifier, the National Electrical Manufacturers Association (NEMA), a nonprofit trade organization, establishes standards which set forth critical mounting dimensions, enclosures, and minimum performance. The standards are too long to discuss thoroughly here, but we will discuss them in some detail, because manufacturers build to these mechanical and electrical guidelines.

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1. POWER SOURCES:

The common power source in the United States is alternating current, 60 hertz.

The power supply may be either single phase or three phase. Generally speaking, single phase is used on electric motors that are less than 1 horsepower. Motors 1 horsepower and larger should be supplied with three phase power if it is available.

Generally available power supply voltages for single phase are 120 volt and 240 volt. 120 volts is generally used on motors no larger than 1/3 horsepower. Three phase voltages generally available are 208 volt, 240 volt, 480 volt and 600 volt. Since there is a voltage drop between the power source and the electric motor, the single phase motors are rated either 115 volt or 230 volt. Three phase motors are rated 200 volt, 230 volt, 460 volt and 575 volt.

Since it is rather easy to build a motor suitable for use on two voltages as long as they are in the ratio of 2-to-1, it is common to specify single phase motors 115/230 volt. It is also common to specify three phase motors 230/460 volt. Occasionally three phase motors are designated 200-230/460 volt. This means that the motor can be operated on 200 volts when it is connected for 230 volts. When the 230 volt motors operated on 200 volts, there is always a sacrifice in torque capability and usually a sacrifice in overload capability.

2. RATINGS:

Motors are rated in horsepower and RPM. The application always determines the horsepower load requirement. The RPM is determined by the load and the drive system which is used to connect the motor to the load. In addition to the horsepower and RPM, consideration should also be given to duty cycle, torques, ambient temperature and service factor.

Horsepower ratings of motors have been standardized by NEMA. See Appendix A. Figure 1, which is an excerpt from the NEMA Standards, lists the horsepower ratings available.

The most commonly used motors are squirrel cage induction motors. The synchronous speed of a motor is determined by the power supply and the number of poles built into the structure of the winding. With a 60 cycle power supply the synchronous speeds available are 3600 RPM, 1800 RPM, 1200 RPM and 900 RPM. Induction motors develop their torque by operating at a speed which is slightly less than synchronous speed. Typically they will operate at 3500 RPM, 1750 RPM, 1160 RPM or 875 RPM.

3. AMBIENT:

The ambient conditions are important in selecting the type of motor. Ambient temperature is the temperature of the air surrounding the motor. Special lubricants and insulation may be necessary for either very high or very low ambient temperature. High moisture, humidity, and/or corrosive environments also must be considered when specifying a motor with specific applications.

Standard motors are designed to operate in an ambient temperature of up to 40 degrees C (104 degrees F) and are supplied with standard high temperature grease . At altitudes greater than 3300 feet, the lower density of the air reduces the motors cooling ability so altitude as well as the ambient temperature must be taken into consideration. Refer to the paragraph dealing with service factors for more information on higher altitude applications.

4. TORQUE:

The turning force which a motor develops is known as torque. The amount of torque necessary to start a load (starting torque) is usually different from the torque required to keep the load moving (full load torque). Loads which have a high breakaway friction or that require extra torque for acceleration, should have a motor specified to have high starting torque.

NEMA specifies design letters to indicate the torque, slip and starting characteristics of three phase induction motors. They are as follows:

Design A motors are similar to Design B motors except that starting currents are not limited for Design A motors by NEMA.

Design B is the general purpose design used for industrial motors. This design has low starting current and normal torques and slip (approximately 3%) which can be used for many types of industrial loads.

Design C motors have high starting torque, low starting current, and also have low slip. This design is good for hard to start loads.

Design D have very high starting torque, high slip, and low starting current. Design D motors are available in 5 to 8% slip and 8 to 13% slip.

See Appendix A. Figure 2 for application information.

5. SERVICE FACTOR:

The service factor shown on the motor nameplate indicates the amount of continuous overload the motor can be subjected to, under nameplate conditions, without damaging the motor. When the voltage and frequency are at the same values as shown on the motor nameplate, the motor may be overloaded up to the horsepower indicated by multiplying the rated horsepower by the service factor. When operated at service factor load, the motor may have an efficiency, power factor, and speed slightly different from those shown on the nameplate.
Service factor can also be used to determine if a motor can be operated continuously at altitudes higher than 3300 feet satisfactorily. At altitudes greater than 3300 feet, the lower density of air reduces the motor's cooling ability thereby causing the temperature of the motor to be higher. This higher temperature is compensated for by reducing the effective service factor to 1.0 on motors nameplated with a 1.15 service factor or greater. If the motor is operated outdoors at higher altitudes. it's sometimes possible to use full horsepower and full service factor since ambient temperatures are usually lower at those altitudes.

6. DUTY CYCLE:

A motor should be rated continuous duty if it operates at full load for 60 minutes or more in any 24 hour period. If the motor operates less than 60 minutes, it may be given an intermittent duty rating or a short time rating. In either case, the time designated is that time which will elapse before the motor reaches full operating temperature.

7. MOUNTINGS:

The most popular motor-mounting style for industry is rigid base. This basic mounting is readily available in all frame sizes and enclosures. It is adaptable to direct-connected loads and to belt or chain driven loads, The most common industrial motor will be arranged with the output shaft, base and conduit box located as in See Appendix A. Figure 4 and See Appendix A. Figure 5. This is called the F-1 mounting position. Other mounting configurations can be found in NEMA publication MGI-4.03.

Other popular mountings for NEMA rated motors are resilient mount, C-face mount and D-flange mount.

Resilient mounted motors are normally used on fan applications or where vibration isolation is desirable. They are generally available up through 2 horsepower.

C-face motors are designed to have something mounted to them such as a gearbox or a pump. C-face motors have a pilot concentric with the shaft and have threaded holes in the face. See See Appendix A. Figure 7.

D flange motors are designed to be mounted to something else. They have a pilot concentric with the shaft and clearance holes in the flange. Refer to See Appendix A. Figure 9.

8. ENCLOSURES:

The two most common types of enclosures for electric motors are open drip proof (ODP) and totally enclosed fan cooled (TEFC). The open drip proof motor allows a free exchange of air from the surroundings to the inside of the motor. See Appendix A. Figure 5. The totally enclosed fan cooled motor (See Appendix A. Figure 4) limits exchange of ambient air to the inside of the motor, thus keeping dirt and water out of the motor. Other types are totally enclosed non-ventilated, totally enclosed air over, and explosion proof. Selection is determined by the environment.

9. INSULATION:

The common insulation classes used in electric motors at the present time are Class B, Class F and Class H. The present frame size assignments are based on Class B insulation. It is the predominant class of insulation used in motor manufacturing today. Based on a 40 degrees C ambient temperature, the Class B insulation is suitable for 80 degrees C rise by resistance. Class F insulation is suitable for 105 degrees C rise by resistance. Class H insulation is suitable for 125 degrees C rise by resistance. Use of Class F insulation or Class H insulation can increase the service factor or the ability to withstand high ambient temperature conditions.

10. FRAMES AND DIMENSIONS:

Standard frame size assignments based on horsepower and speed are shown in See Appendix A. Figure 1. Standardized frame sizes throughout the industry result in common dimensions for shaft diameter. shaft height, shaft length, bolt hole spacing and location.

In addition to standard foot mount dimensions, there are standardized dimensions for C-face, D-flange, P base, JM and JP pump mounts and west coast pump mounts.

11. EFFICIENCY:

The efficiency of an electric motor is the usable horsepower that you get out of the motor as a percent of the power that goes into the motor. Unused energy is converted to heat in the motor. The user pays for the energy that goes into the motor but only gets benefit from the output of the motor. The difference, the losses, are consumed and paid for with no benefit received

Energy efficiency is always important since the losses are paid for whenever the motor is running. Energy efficiency is particularly important if power costs are high or if the motor operates for long periods of time. Smaller motors are generally less efficient than larger motors. Motors operated at less than half load are usually inefficient.

The See Appendix A. Figure 3 will allow you to make an easy determination of whether or not the higher cost for a premium efficiency motor can be quickly recovered.

12. V-BELT APPLICATION:

Other than direct coupling, v-belt drives are the most common and easiest way of connecting a motor to the load. Standard bearings in the electric motor will handle the radial load imposed by a v-belt drive provided the v-belt drive is designed in accordance with See Appendix A. Figure 6.

13. MULTISPEED MOTORS:

Multispeed motors are motors that are reconnectable so that they can be operated at more than one speed.

Multispeed motors can be either single winding or two winding. The single winding motors are reconnectable in such a way that they can provide two speeds that are in the ratio of 2-to-1. Two winding motors have two separate windings that can be wound for any number of poles so that speed ratios other than 2-to-1 can be obtained. Ratios greater than 4-to-1 are usually impractical due to the size and weight of the motor.

Single phase multispeed motors that operate with a centrifugal switch are usually impractical.

Power output of multispeed motors can be proportioned for each different speed. These motors are designed with output horsepower capacity in accordance with one of the following load characteristics.
Variable-torque motors have a speed torque characteristic that varies as the square of the speed. For example, an 1800/900 RPM motor that develops 10 HP at 1800 RPM produces 2.5 HP at 900 RPM. Since some loads such as centrifugal pumps, fans, and blowers have a torque requirement that varies as the square of the speed, this motor design is adequate for them.

Constant-torque motors can develop the same torque at each speed, thus power output varies directly with speed. For example, a two speed motor rate at 10 HP at 1800 RPM would produce 5 HP at 900 RPM. These motors are used in applications with constant torque requirements such as mixers, conveyors, and positive displacement compressors.

Figure 1:
TOTALLY ENCLOSED, FAN-COOLED MOTORS

T Frames, Design B, 1.15 Service Factor, 60 Cycles, Class B Insulation

Hp	Speed, RPM			
	3600	**1800**	**1200**	**900**
.50	—	—	—	143T
.75	—	—	143T	145T
1.00	—	143T	145T	182T
1.50	143T	145T	182T	184T
2.00	145T	145T	184T	213T
3.00	145T	182T	213T	215T
5.00	182T	184T	215T	254T
7.50	184T	213T	254T	256T
10.00	213T	215T	256T	284T
15.00	215T	254T	284T	286T
20.00	254T	256T	286T	324T
25.00	256T	284T	324T	326T
30.00	284TS	286T	326T	364T
40.00	286TS	324T	364T	325T
50.00	324TS	326T	365T	404T
60.00	326TS	364TS*	404T	405T
75.00	364TS	365TS*	405T	444T
100.00	365TS	404TS*	444T	—
125.00	404TS	405TS*	445T	—
150.00	405TS	444TS*	—	—
200.00	444TS	444TS*	—	—
250.00	445TS	—	—	—

DRIP-PROOF MOTORS

T Frames, Design B, 1.0 Service Factor

Hp	Speed, RPM			
	3600	**1800**	**1200**	**900**
.50	—	—	—	143T
.75	—	—	143T	145T
1.00	—	143T	145T	182T
1.50	143T	145T	182T	184T
2.00	145T	145T	184T	213T
3.00	182T	182T	213T	215T
5.00	184T	184T	215T	254T
7.50	213T	213T	254T	256T
10.00	215T	215T	256T	284T
15.00	254T	254T	284T	286T
20.00	256T	256T	286T	324T
25.00	284TS	284T	324T	326T
30.00	286TS	286T	326T	364T
40.00	324TS	324T	364T	325T
50.00	326TS	326T	365T	404T
60.00	364TS	364TS*	404T	405T
75.00	365TS	365TS*	405T	444T
100.00	405TS	404TS*	444T	—
125.00	444TS	444TS*	445T	—
150.00	445TS	445TS*	—	—

*When motors are to be used with V-belt or chain drives, the correct frame size is the frame size shown, but with the suffix letter “S” omitted.

Figure 2:
CHARACTERISTICS AND APPLICATIONS OF POLYPHASE INDUCTION MOTORS

Design A motor performance characteristics are similar to those for Design B motors except that the starting current is higher than the values shown in the Table.

Classification	Starting Torque (% Rated Load Torque)	Breakdown Torque (% Rated Load Torque)	Starting Current (% Rated Load Current)	Slip	Typical Applications	Relative Efficiency
Design B Normal starting torque and normal starting current	120-250	200-270	600-700	1.5-3%	Fans, blowers, centrifugal pumps and and compressors, motor-generator sets, etc., where starting torque requirements are relatively low	High
Design C High starting torque and normal starting current	200-250	190-225	600-700	1.5-3%	Conveyors, crushers, stirring machines, machines, agitators, reciprocating pumps and compressors, etc., where starting under load is required	High
Design D High starting torque and high slip	275	275	600-700	5-8%	High peak loads with or without fly wheels such as punch presses, shears, elevators, extractors, winches, hoists, oil-well pumping and wire-drawing machines.	Medium

Figure 3:
MOTOR SELECTION CHART

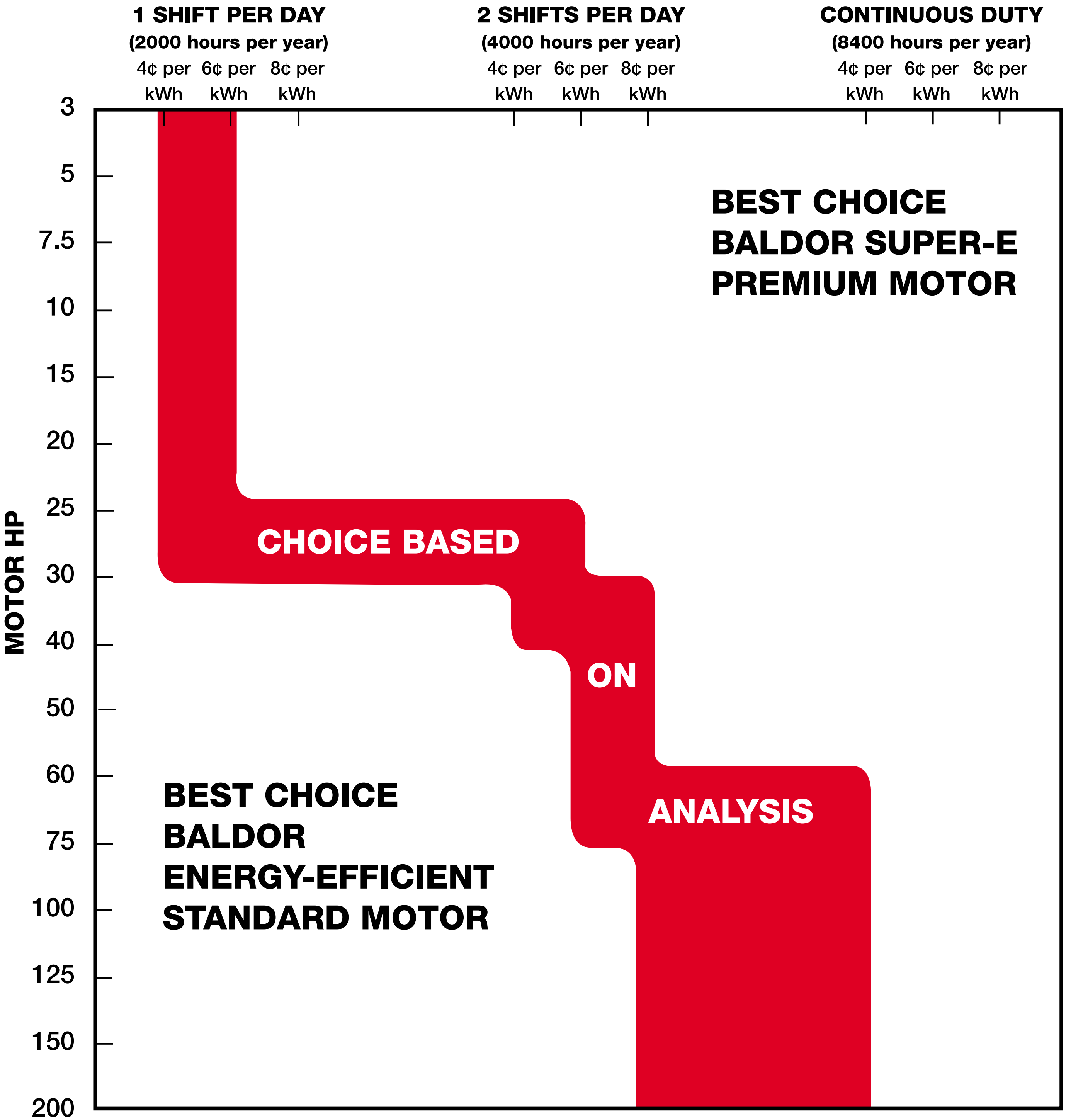

Figure 4:

Figure 5:

Figure 6:
INTEGRAL HORSEPOWER MOTORS/POLYPHASE INDUCTION

T Frames, V-Belt Sheave

Frame No.	Horsepower at Synchronous Speed, RPM				Conventional A, B, C, D & E		Narrow 3V, 5V & 8V	
	3600	1800	1200	900	Min. Pitch Dia. Inches	*See Note 1 Max. Width	Min. Outside Dia. Inches	*See Note 2 Max. Width
143T	1.5	1	.75	.5	2.2		2.2	
145T	2-3	1.5-2	1	.375	2.4		2.4	
182T	3	3	1.5	1	2.4		2.4	
182T	5	—	—	—	2.6		2.6	
184T	—	—	2	1.5	2.4		2.4	
184T	5	—	—	—	2.6		2.6	
184T	7.5	5	—	—	3.0		3.0	
213T	7.5-10	7.5	3	2	3.0	See Note 3	3.0	See Note 4
215T	10	—	5	3	3.0		3.0	
215T	15	10	—	—	3.8		3.8	
254T	15	—	7.5	5	3.8		3.8	
254T	20	15	—	—	4.4		4.4	
256T	20-25	—	10	7.5	4.4		4.4	
256T	—	20	—	—	4.6		4.4	
284T	—	—	15	10	4.6		4.4	
284T	—	25	—	—	5.0		4.4	
286T	—	30	20	15	5.4		5.2	
324T	—	40	25	20	6.0		6.0	
326T	—	50	30	25	6.8		6.8	
364T	—	—	40	30	6.8		6.8	
364T	—	60	—	—	7.4		7.4	
365T	—	—	50	40	8.2		8.2	
365T	—	75	—	—	9.0		8.6	
404T	—	—	60	—	9.0		8.0	
404T	—	—	—	50	9.0		8.4	
404T	—	100	—	—	10.0		8.6	
405T	—	—	75	60	10.0		10.0	
405T	—	100	—	—	10.0		8.6	
405T	—	125	—	—	11.5		10.5	
444T	—	—	100	—	11.0		10.0	
444T	—	—	—	75	10.5		9.5	
444T	—	125	—	—	11.0		9.5	
444T	—	150	—	—	—		10.5	
445T	—	—	125	—	12.5		12.0	
445T	—	—	—	100	12.5		12.0	
445T	—	150	—	—	—		10.5	
445T	—	200	—	—	—		13.2	

Figure 7:

Figure 8:

CHANGES IN THE PERFORMANCE OF ALTERNATING-CURRENT INDUCTION MOTORS — (Applicable to 2, 4, 6 and 8-pole motors only)

	Change in Design Voltage	
Characteristic	**110%**	**90%**
Torque[1]		
Starting and maximum running	Increase 21%	Decrease 19%
Speed[2]		
Synchronous	No change	No change
Full-load	Increase 1%	Decrease 1.5%
Percent Slip	Decrease 17%	Increase 23%
Efficiency		
Full-load	Increase 0.5 to 1 point	Decrease 2 points
3/4-load	Little change	Little change
1/2-load	Decrease 1 to 2 points	Increase 1 to 2 points
Power factor		
Full-load	Decrease 3 points	Increase 1 point
3/4-load	Decrease 4 points	Increase 2 to 3 points
1/2-load	Decrease 5 to 6 points	Increase 4 to 5 points
Current		
Starting	Increase 10 to 12%	Decrease 10 to 12%
Full-load	Decrease 7%	Increase 11%
Temperature Rise	Decrease 3° to 4° C	Increase 6° to 7° C
Maximum Overload Capacity	Increase 21%	Decrease 19%
Magnetic Noise	Slight increase	Slight decrease

[1] The starting and maximum running torque of AC induction motors will vary as the square of the voltage.
[2] The speed of AC induction motors will vary directly with the frequency.

Figure 9: