ENGINEERING DATA

Aerovent • *TC* Ventco • Fiber-Aire • Twin City Fan & Blower • *TC* Axial • Clarage

Motor Classifications

Introduction

Motors can be classified in many ways. This engineering data letter will cover the following motor classifications: Motor Designs and Standard vs. Premium Efficiency. In addition, this letter will provide a general formula to determine the operating cost of a motor. For further information, please refer to ED-800: Integral AC Motor Selection and Application Guide for Fans; and ED-1100: Single-Phase AC Induction Squirrel Cage Motors.

Motor Designs

Motors can be designed with emphasis on one or more torque characteristics to produce motors for various applications. Torque characteristics are:

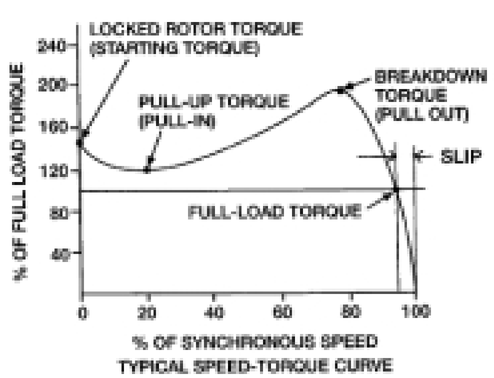
Locked Rotor Torque – the minimum torque that it will develop at rest for all angular positions of the rotor, with rated voltage applied at rated frequency.

Pull-up Torque – the minimum torque developed by the motor during the period of acceleration from rest to the speed at which breakdown torque occurs. For motors that do not have a definite breakdown torque, the pull-up torque is the minimum torque developed up to rated speed.

Breakdown Torque – maximum torque that it will develop with rated voltage applied at rated frequency, without an abrupt drop in speed.

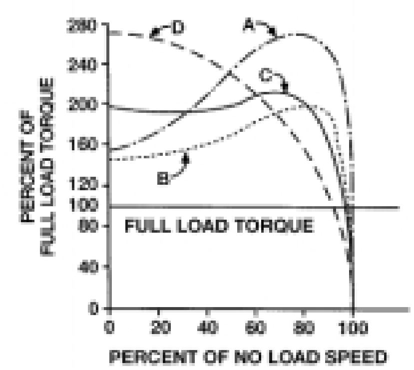
Rated-Load Torque – torque necessary to produce its rated horsepower at rated-load speed. In pounds at a 1-foot radius, it is equal to the horsepower times 5252 divided by the rated-load speed.

Figure 1. Motor Designs



Because of the variety of torque requirements, the National Electrical Manufacturers Association (NEMA) has established different designs to cover almost every application including Fans. These designs take into consideration starting current and slip, as well as torque. These designs should not be confused with various classes of insulation, which are also designated by letter. NEMA classifies motors by design letters A, B, C, and D. The design letter is an indication of the shape of the torque speed curve.

Figure 2. Torque Speed Curves



A comparison of the different designs is summarized in the chart on page 2.

Standard vs. High Efficiency

High efficiency motors are designed to save energy. By conserving energy, fewer generating facilities are required. They also result in lower operating costs.

The use of high efficiency motors has not been readily accepted for two reasons. First, it is difficult to see the cost savings because motors are sold by output rating (horsepower) rather than input wattage. In contrast, it is much easier to see the cost savings when you buy a 34 watt bulb versus a 40 watt bulb. The second reason is that, while lights are usually on or off, a motor can operate at full load, no load, or in between.

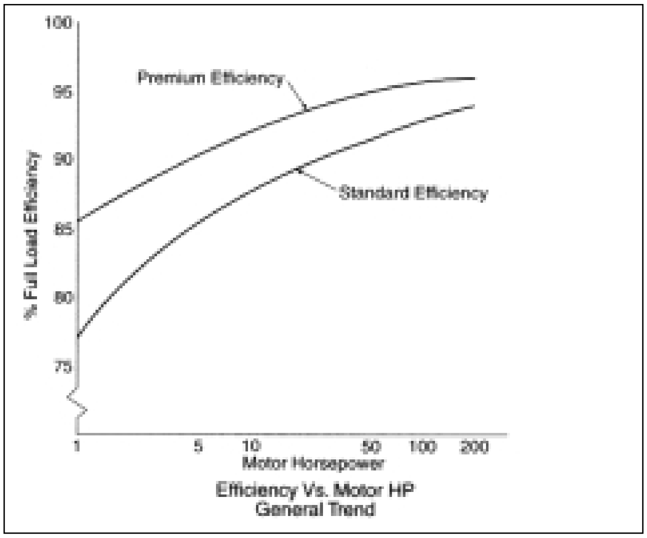
Premium or high efficiency motors, with their enhanced designs, result in lower operating cost at any level of loading including no load. For example, the no load losses of a five horsepower high efficiency motor might be 215 watts. The no load losses of a standard motor of the same type might be 330 watts.

Table 1. NEMA Design Comparison

NEMA DESIGN	STARTING CURRENT	LOCKED ROTOR	BREAKDOWN TORQUE	% SLIP	APPLICATIONS
B	Medium	Medium Torque	High	Max. 5%	Standard industrial motor with reasonable starting torque with moderate starting current. Normal starting torque for Fans, Blowers, rotary pumps. Constant load speed.
C	Medium	High Torque	Medium	Max. 5%	For hard to start loads. High inertia starts such as large centrifugal blowers, fly wheels, and crusher drums. Constant load speed.
D	Medium	Extra High Torque	Low	5% or more	Very high inertial and loaded starts. Variable load speed. High slip. “Spongy” characteristics when loads are changing. Efficiency at full load is rather poorly-used on applications where torque is primary importance. Punch presses, shears and forming machine tools. Cranes, hoists, elevators and oil well pumping jacks.

Note: NEMA design A is a variation of design B having higher locked rotor current

Figure 3. Standard versus High Efficiency



Converting electrical energy to mechanical energy is never perfect. It does become easier to approach 100% perfection with large motors than with small. The efficiency of standard industrial three phase motors usually runs from a level of approximately 75% at 1 HP to 94% at 200 HP.

The following table shows the losses due to each one of the five categories and what was done to improve efficiency.

Table 2.

CATEGORY	LOSS	DESIGN CHANGES
Stator Res. Loss	30%	Increased the wire size
Rotor Res. Loss	20%	Used larger rotor bars
Core Loss	19%	Improved steels, made thinner laminations and insulated them more effectively from each other
Friction and Windage Loss	13%	Reduced fan size due to above improvements
Stray Load Loss	18%	Improved manufacturing techniques

There are some cautions when using high efficiency motors. High efficiency motors run somewhat faster (less slip) than their less efficient counterparts. A high efficiency motor might run at a full load speed of 1760 RPM. The motor it replaces may run at 1740 RPM. With fans, there can be reduced expected savings. Centrifugal fans, along with other types of variable torque loads, such as pumps, require horsepower proportional to speed cubed. For example, if a motor drives a fan with a belt drive and the fan speed is 650 RPM, changing the motor and using the same exact pulley and belt would increase the fan’s speed and the horsepower required. This could reflect back as extra energy drawn from the power system. However, if an adjustment is made in the ratio between the pulleys to restore the fan speed to the original value, then the anticipated savings will be realized. Therefore, it is desirable to look at efficiency upgrading as a system rather than strictly a motor consideration.

Because of their reduced losses, high efficiency motors run at lower temperatures than equivalent standard motors. This results in longer insulation and lubricant life and less downtime. Inherent in their design is the ability to tolerate wider voltage variations and higher ambient temperatures.

An additional benefit is that by generating less waste heat in the space around the motor, building ventilation and/or air conditioning requirements are reduced. This can result in additional savings.

Here is a good "rule of thumb" to use to gain a perspective on the costs to operate motors and some savings due to high efficiency motors. At 5 cents per kilowatt hour it costs $1 per horsepower per day to operate a motor at full load. Now consider a 100 HP motor operating continuously in a 10 cents per kilowatt hour area. The annual cost of operation comes out to be approximately $70,000. This can represent about 25 times the first cost of the motor. By spending an extra 30% ($750) to get a high efficiency unit (2.4% more efficient), the annual operating cost could be reduced by $1800.

Motor Operating Cost Formulas

Kilowatt Hours = $\frac{\text{HP* x 0.746 x Hours of Operation}}{\text{Motor Efficiency}}$

* Average load HP (may be lower than motor nameplate HP)

Useful Constants

Average hours per month	=	730
Hours per year	=	8760
Average hours of darkness per year	=	4000
Approximate ave. hours per month (single shift operation)	=	200

Annual Savings Formula

S = 0.746 x HP x C x N (1/Es – 1/Epe)

S = Dollars saved per year
HP = Horsepower required by load
C = Energy cost in dollars per kilowatt hour
N = Annual running hours
Es = Efficiency of standard motor (decimal)
Epe = Efficiency of premium motor (decimal)

General Formulas - All Loads

Kilowatt Hours = $\frac{\text{Watts x Hours of Operation}}{1000}$

Annual Operating Cost* = Kilowatt hours x Average cost per kilowatt hour

* does not include power factor penalty or demand charges which may be applicable in some areas.

Twin City Fan Companies, Ltd.

Designers & Manufacturers of Air Moving Equipment

5959 Trenton Lane · Minneapolis, MN 55442-3237
Phone (763) 551-7600 · Fax (763) 551-7601 · www.twincityfan.com

MEMBER

ISO 9001 CERTIFIED

3MPP03/04