T.I.P.S.

TECHNICAL INFORMATION AND PRODUCT SHEETS

LARGE HORSEPOWER MOTORS AND EFFICIENCY

When it comes to large motors, 500 HP and up, efficiency is usually not one of the concerns during the bidding process. Customer and manufacturer alike are primarily concerned with other technical characteristics such as starting torque, acceleration time, inrush current and slip. While all of these factors are more important than the efficiency of the motor – after all, it's no use having a 99% efficient motor if it won't drive the load – efficiency shouldn't be ignored completely.

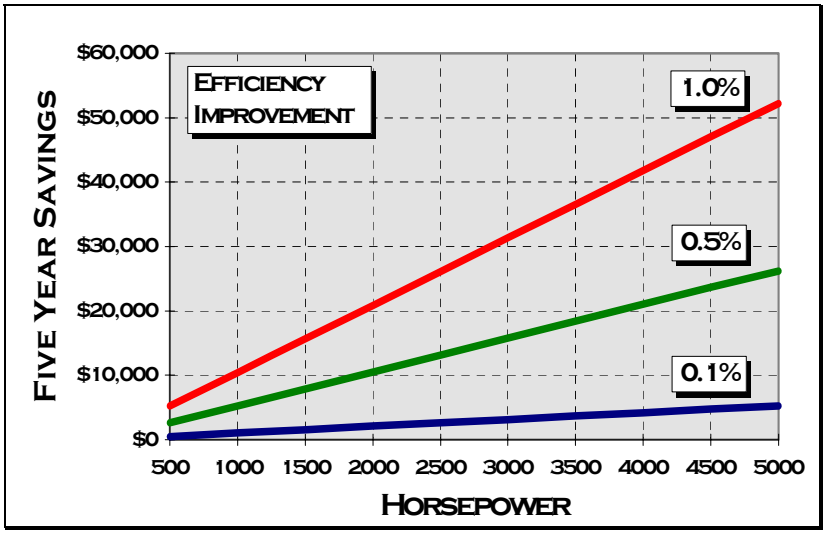
The information contained in the specifications will define the technical requirements of the motor. It is then up to the manufacturer to design a motor which will meet the conditions. If efficiency is not included, it will not be a priority in the design.

One of the characteristics that has the greatest effect on efficiency is the starting torque of the motor – typically, the higher the starting torque, the lower the efficiency. However, the starting torque is often over-specified due to overly compounded safety factors. As a result, the manufacturer designs a motor that will be capable of producing the overly conservative torque specified with a severe detrimental effect on the efficiency. Motors should be sized to match the load as closely as possible, with a *reasonable* safety factor.

DEFINING THE LOAD REQUIREMENTS

- The speed-torque characteristics of the load under the most stringent starting conditions*
- When required, the speed-torque characteristics of the load and the expected voltage at the motor terminals during reacceleration conditions, and the length of maximum voltage interruption*
- The total load inertia (Wk^2) referred to the motor shaft*
- The expected voltage under starting conditions or the system short circuit in kilovolt amperes at the motor terminals
- The type of coupling and the overhung moment on the motor shaft

* *In accordance with NEMA MG-1*



Savings in operating costs for the specified efficiency improvement over 95% for a motor operating 8,000 hours per year at 90% load and energy costs at 3.5 ¢/kWh.

SHORT TERM INVESTMENT IN EFFICIENCY GIVES LONG TERM BENEFITS

In addition to technical considerations, most purchasers and manufacturers place a higher priority on capital cost than on efficiency. However, given the typical loading and duty cycle on large motors, even a small improvement in efficiency (a few tenths of a percentage point) can result in significant cost savings over the long term.

How to Specify High-Efficiency

Since large, medium-voltage motors are typically custom built for each application, there is an opportunity for the customer to influence the design process. The specifications for each project can include statements which will influence the manufacturer to consider efficiency as one of the design parameters.

Unlike motors in the 1-200 HP range, there are no universally recognized definitions of 'high-efficiency.' Literally speaking, all large motors have a 'high' efficiency. So a general statement such as "must be high-efficiency" is not sufficient.

On the other hand, it is very difficult for anyone other than a motor designer to determine a realistic minimum efficiency to put in the specifications — the attainable efficiency range will vary greatly depending on the torque and locked-rotor current limits specific to each application. The actual efficiency of the motor is best left to the designers. The specifications should only offer guidance into the relative worth of efficiency improvements to the customer.

The most effective way to communicate the importance of efficiency to the supplier is to attach a value to each kW of losses. This provides the manufacturer with the flexibility to design a motor which meets the technical requirements, yet ensures that consideration is given to the overall efficiency of the motor — the higher the value of each kW of losses, the higher the priority placed on efficiency.

Valuation of Losses

Attaching a dollar value to the energy losses allows the designer to consider the technical and cost related trade-offs associated with improving the efficiency. The objective is to look at efficiency from an economic standpoint instead of purely as a technical issue — each bid can be adjusted by the dollar value of the losses.

There are several ways to calculate the value of losses, from a simplified version to a more complex equation that takes into account the time value of money and reflects the rising costs of electricity.

Incorporating Efficiency into the Motor Specs

Once the value of losses has been determined, the specifications can include a statement such as:

"Motor losses will be evaluated at $1,500 per kW."

When the bids are tendered, the evaluated price is calculated as the sum of the capital cost plus the value of the losses at the operating load.

In addition, a statement concerning efficiency should be added to the section dealing with the performance characteristics of the motor, including limits on slip, inrush current and starting torque:

"Where these limits will have an adverse effect on other characteristics, particularly efficiency, the motor vendor shall state the effect and recommend preferred values."

Calculating the Value of Losses

Simple Loss Evaluation

$$P = [(hrs \times \$/kWh + (12 \times \$/kW)] \times n$$

Capitalized Value of Losses

$$P = \left[1 - \left(\frac{1}{1+r-e}\right)^{n}\right] \times \frac{(hrs \times \$/kWh) + (12 \times \$/kW)}{r-e}$$

P = value of losses ($/kW)
hrs = annual operating hours
$/kWh = energy consumption charge
$/kW = monthly demand charge
n = capital recovery period (years)
r = discount rate
e = energy escalation rate minus the inflation rate — can be negative number (ignore if unavailable)