Suggested Actions

- Keep track of your motors through a motor system management plan. Consider times when motors can be shut down, including shift changes, lunch breaks, or during process interruptions.
- Energy saving opportunities often exist when motors drive loads in parallel, such as compressors or pumps. Evaluate sequencing of these motors.
- Install automatic shutdown timers so motors will be turned off when they would otherwise be running idle or unloaded for intervals longer than the rest intervals identified in NEMA MG 10-2001.
- Shut down equipment that is energized but not in use for significant periods of time.
- Consider adjustable speed drives (ASDs), soft starters, wye-delta starting or autotransformers to reduce starting stresses on equipment that requires frequent starting and stopping.

Resources

National Electrical Manufacturers Association (NEMA)—Visit www.nema.org for more information. When making the decision to stop a motor, refer to NEMA MG 10-2001 "Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors." For large induction motors, refer to NEMA MG 1-2006 "Motors and Generators" Part 20.12.

U.S. Department of Energy—For additional information or resources on motor and motor-driven system efficiency improvement measures, visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices, or contact the EERE Information Center at (877) 337-3463.

Turn Motors Off When Not in Use

Motors use no energy when turned off. Reducing motor operating time by just 10% usually saves more energy than replacing a standard efficiency motor with a NEMA Premium® efficiency motor. In fact, given that 97% of the life cycle cost of purchasing and operating a motor is energy-related, turning a motor off 10% of the time could reduce energy costs enough to purchase three new motors.

However, the belief that stopping and starting motors is harmful persists. Many users believe that repeated motor starts will use more energy than constant operation, increase utility demand charges, and shorten motor life. While these opinions are not totally without basis, they do need to be put into proper perspective.

When started, a motor accelerates and draws more power than when it is operating steadily at full load. While a typical NEMA Design B motor may draw from four to eight times the full-load *current* during starting, the power factor is low so the input power is not four to eight times rated load *power*. Starting usually takes under 2 seconds and is rarely over 10 seconds, even for large high inertia loads. Just 1 minute of additional running time consumes far more energy than a motor starting event.

Another motor starting concern involves increased utility demand charges. Again, the *excess starting demand* is small due to the short duration of the motor starting interval. Peak demand charges are generally based upon a facility's average energy use over a fixed or rolling average window of 15 to 60 minutes in duration. Check with your utility to determine how they assess peak demand charges.

Starting Stresses

Starting stresses a motor by:

- Applying higher than rated full load torque to the shaft during acceleration
- Applying high magnetic forces to the rotor cage and winding end turns
- Heating the stator winding and the rotor cage.

Frequent torque shocks to the shaft from starting could shorten shaft life through metal fatigue. However, most shaft failures are attributed to bearing failures, shock, excessive belt tension, misapplication, or creep during storage (large motors). Overheating the stator winding and the rotor cage occurs if frequency of starts and duration of rest time between starts exceeds the NEMA design range. Heat from exceeding these limits can degrade winding insulation and cause thermal stressing of the rotor cage, leading to cracks and failed end-ring connections.

Repeated Motor Starts and Stops

While it is true that starting stresses a motor, motors are designed to be started. For example, motors in applications like lift pumps or irrigation wells start and stop quite frequently, while lasting for 15 years or more. As long as the frequency of starts is not excessive, lifetime is not significantly affected.

NEMA provides standards for starting duty which consider inertia of the load—an important factor in starting stress. NEMA also provides guidance relating to start-run-stop-rest cycles that are often employed in energy management programs.

Frequent stopping and starting, even within NEMA limits, does stress a motor due to mechanical flexing of the coils and rotor overheating during acceleration, but there is no known relationship between number of motor starts and *normal* motor life expectancy. Each start is one factor in the life expectancy and reliability of the motor and some reduction in life expectancy and reliability must be accepted when a motor is continuously applied at the upper range of its starting duty.

The greatest stress of pushing the limits on starting frequency is thermal. Multiple other factors also contribute to temperature rise. When operating in the upper range of starting duty, take these steps to ensure that you are well within tolerances on other sources of thermal stress:

- Keep the motor clean so air flow and heat transfer are not impeded
- Keep supply voltage nominal, avoiding voltage unbalance, under-voltage, and harmonic voltages
- Do not overload the motor
- Derate any motor used in severe ambient environments, such as over 3,000 feet altitude or above 40°C.

You may find that you can substantially increase the time your motors are shut down without approaching the NEMA MG 10-2001 starting duty limits.

Additional Information

- NEMA MG 1-2006 provides a table on the maximum inertia load for starting induction motors of various ratings. Motors driving loads that do not exceed these inertia limits can be started twice in immediate succession when the motor is initially at ambient temperature.
- NEMA MG 10-2001 (Table 7) gives the maximum number of allowable starts per hour for motors of various horsepower and synchronous speed ratings. The table indicates how frequently motors can be started with a *rest period* between starts and provides a minimum length for that rest period.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

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