Energy Tips – Motor Systems

Motor Systems Tip Sheet #6 • September 2005

Industrial Technologies Program

Suggested Actions

If nuisance tripping occurs:

- Make sure power factor correction capacitors are installed ahead of the starter.
- Refer to Section 430 of the latest National Electric Code for guidance on increasing the instantaneous trip level of your circuit protector. The Code has been modified to allow adjustments to a greater allowable trip setting when nuisance trips occur. Note that the Code can be quite complicated and exceptions do exist. Don't hesitate to contact a licensed professional electrical engineer to resolve motor protection problems.
- If adjusting the trip setting is not sufficient, the circuit protector can be replaced with a circuit protector with a mechanical delay that lets it ride through half a cycle of current above the nominal setting.

Resources

National Electrical Manufacturers Association (NEMA)—For additional information on NEMA Premium standards, see the Motor Tip Sheet #1 (DOE/GO-102005-2019) on this topic or visit www.nema.org.

U.S. Department of Energy—For assistance in diagnosing nuisance motor trips and related information on industrial energy efficiency measures contact the EERE Information Center at (877) 337-3463. Visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices to access additional resources and information on training.

Avoid Nuisance Tripping with Premium Efficiency Motors

In most cases, upgrading to NEMA Premium™ efficiency motors has no noticeable impact on the electrical system. However, in rare cases nuisance trips can occur during startup. Addressing this topic requires an understanding of starting current.

The National Electrical Manufacturers Association (NEMA) recognizes and describes two components of starting current, instantaneous peak inrush and locked rotor current. Nuisance tripping has been primarily associated with the instantaneous peak inrush, which is a momentary current transient that occurs immediately (within half an AC cycle) after contact closure. Locked rotor current is the root-mean-square or RMS current that establishes following the peak inrush; the current remains near the locked rotor value during acceleration until the motor approaches its operating speed. (Note: The terms inrush or starting current are often used to mean locked-rotor current.)

NEMA Premium motors have slightly higher locked-rotor currents and Locked-Rotor Code letters than lower-efficiency motors of the same rating. However, most NEMA Premium motors are NEMA Design B and are subject to the same maximum allowable locked-rotor current as their standard-efficiency counterparts. Locked-rotor current for specific new motor models can be looked up in the *MotorMaster+ 4.0* software or deciphered from the locked-rotor code letter on the motor nameplate. This letter, usually just designated as "Code" is not the same as the motor design letter code. Locked-rotor code expresses current in kilovolt amperes (kVA) per horsepower (hp). The code letters are defined as follows:

Locked-Rotor Code, kVA/hp			
A	0-3.15	G	5.6-6.3
B	3.15-3.55	H	6.3-7.1
C	3.55-4.0	J	7.1-8.0
D	4.0-4.5	K	8.0-9.0
E	4.5-5.0	L	9.0-10.0
F	5.0-5.6	M	10.0-11.2

Example

The maximum locked-rotor current for a Code C, 460-volt, 100-hp motor is determined as follows.

$$\text{LR Current} = \text{Motor horsepower} \times (\text{Maximum kVA/hp/Supply voltage in kV}) / \sqrt{3}$$

$$= 100 \text{ hp} \times \{(4.0 \text{ kVA/hp} / 0.46 \text{ kV}) / \sqrt{3}\}$$

$$= 502 \text{ Amps}$$

The NEMA table actually continues all the way to letter V with current increasing about 12.3% for each letter increment. Only small and non-NEMA Design B motors have Codes beyond L.

The ratio of peak inrush to locked-rotor current tends to increase with higher-efficiency motors due to their lower power factor under locked rotor conditions.

While NEMA Design B standards limit locked-rotor current, no standard limits the peak-inrush current. Fortunately, peak-inrush current is usually not a problem because it lasts only a few milliseconds. However, it can be a problem when the motor controller uses instantaneous magnetic-only circuit protectors that react in less than a single AC cycle. That is because peak inrush can be as high as 2.8 times the RMS locked rotor current and may exceed the circuit protector current setting.

A motor may trip on peak-inrush current and start successfully on the next attempt. The exact peak-inrush current depends on the moment when contacts close in the AC voltage cycle, and how close to simultaneously the three-phase contacts close.

Nuisance trips are unlikely to occur in situations without instantaneous magnetic-only circuit protectors when the replacement motor is a NEMA Premium Design B motor of the same speed and horsepower. Even if instantaneous magnetic-only circuit protectors are present, you may not have a problem with nuisance trips. Many motor manufacturers offer NEMA Premium Design A motors that meet Design B torque requirements but exceed Design B locked-rotor current limits. Some of the most efficient motors are Design A, so do not limit choices to Design B unless you have locked-rotor current concerns.

About DOE's Industrial Technologies Program

The Industrial Technologies Program, through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. The Industrial Technologies Program is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

The Industrial Technologies Program encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following eight energy and resource intensive industries:

- Aluminum
- Forest Products
- Metal Casting
- Petroleum
- Chemicals
- Glass
- Mining
- Steel

The Industrial Technologies Program and its BestPractices activities offer a wide variety of resources to industrial partners that cover motor, steam, compressed air, and process heating systems. For example, BestPractices software can help you decide whether to replace or rewind motors (MotorMaster+), assess the efficiency of pumping systems (PSAT), compressed air systems (AirMaster+), steam systems (Steam Scoping Tool), or determine optimal insulation thickness for pipes and pressure vessels (3E Plus). Training is available to help you or your staff learn how to use these software programs and learn more about industrial systems. Workshops are held around the country on topics such as "Capturing the Value of Steam Efficiency," "Fundamentals and Advanced Management of Compressed Air Systems," and "Motor System Management." Available technical publications range from case studies and tip sheets to sourcebooks and market assessments. The Energy Matters newsletter, for example, provides timely articles and information on comprehensive energy systems for industry. You can access these resources and more by visiting the BestPractices Web site at **www.eere.energy.gov/ industry/bestpractices** or by contacting the EERE Information Center at **877-337-3463** or via email at **www.eere.energy.gov/informationcenter/.**

BestPractices is part of the Industrial Technologies Program Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

EERE Information Center
1-877-EERE-INF
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