Evaluating EPACT’s impact

By Greg Paula, Associate Editor

Passed six years ago, the Energy Policy and Conservation Act (EPACT) was designed to help cut the amount of energy consumed by various industrial and consumer products. The act outlawed certain types of fluorescent tubes, for example, and set standards for both alternative-fuel vehicles in large fleets and low-flow toilets. Another main provision required manufacturers to stop offering motors with rated load efficiencies that fall below a specified minimum. This could be one of EPACT’s most significant measures, because approximately 70 to 75 percent of the electricity consumed by industry is used to run motors.

Whereas many of EPACT’s provisions took effect soon after the act was passed, motor manufacturers had until October 1997 to implement the measure. The act stipulates progressively higher efficiencies for higher horsepower. All general-purpose, three-phase induction motors between 1 and 200 horsepower are affected.

"Motors that had efficiencies high enough to make them compliant with EPACT had been available long before EPACT was passed," said Kitt Butler, industrial sales and marketing manager at Advanced Energy Corp. (AEC) in Raleigh, N.C., “but they were approximately 20 percent more expensive than their less-efficient counterparts. Now that the legislation has gone into effect, manufacturers no longer have the option of making a less expensive, less efficient motor.”

AEC has completed the first in a series of studies to determine if newer motors are complying with the minimum EPACT-specified energy efficiency. The Motors and Drives Laboratory of AEC—a nonprofit, independent engineering firm that focuses on energy-efficiency issues—was the first motor-testing laboratory to be certified through the National Voluntary Laboratory Accreditation Program, a requirement under EPACT. Six other laboratories, most of which are owned and operated by motor manufacturers, also have been accredited.

The AEC study tested 20-horsepower, 1,800-rpm, totally enclosed, fan-cooled motors from 15 manufacturers. This type was chosen because motors of relatively low horsepower are by far the most commonly used (about 80 percent of installed motors are 25 horsepower or less). The EPACT efficiency level specified for motors of this rating is 91.0. The study was designed to determine if these new motors perform as advertised and if their higher efficiencies had any consequence on performance.

One problem with testing new motors is that they sometimes exhibit a break-in phenomenon, which leads to higher efficiencies with repeated tests. To reduce the possible effects of this phenomenon, AEC ran all motors at no load for at least 8 hours prior to efficiency testing.
Locked-rotor current, locked-rotor torque, and breakdown torque tests were performed at 60 hertz and near rated voltage. The goal of this study is to see if the motors meet the minimum efficiency, which EPACT specifies as the nominal efficiency for motor nameplates defined by the National Electrical Manufacturers Association (NEMA). Every NEMA-defined efficiency has an associated minimum efficiency, which allows for normal variation in motor manufacturing. For a nameplate efficiency of 91.0, the minimum value is 89.5, so no motor with that nameplate should perform below 89.5 for full-load efficiency.

Overall, only one motor in this test group did not meet the NEMA-defined minimum efficiency. (The 7-percent NEMA minimum failure rate for this group is an improvement over the 20-percent failure rate for all previous new motors tested at AEC.) Another motor exceeded its nominal nameplate efficiency by 1.5 points. Cost of operation—based on full-load operation for 8,000 hours per year at an average electricity cost of 5 cents per kilowatt-hour—varies from $6,452 to $6,691, or about $240 per year.

The legislation does not cover efficiency at other than full load, but motors often run at lower levels and are generally more efficient there. The tested values of efficiencies at 75-percent load range from 89.7 to 93.0. At 50-percent load, the tested values of efficiencies range from 89.0 to 92.9 and the cost of operation varies from $3,212 to $3,353, or about $141 per year. The tests confirmed that the part-load efficiencies are generally higher than at full load.

Other performance characteristics not covered by EPACT are useful as reliability indicators. Among these is the temperature rise of the stator winding above ambient temperature after the motor has thermally stabilized at rated load and rated voltage conditions. For all new class F 20-horsepower motors tested at AEC except for those in this study, the average temperature rise is 59.8°C.

A common rule of thumb for electrical insulation is that its life is shortened by one-half for every 10°C increase in operating temperature; for bearing lubricant, that happens for every 15°C increase. The variation from minimum to maximum temperature for these motors is about 40°C. This magnitude of difference in temperature rise can impact motor life. The rise for all motors was within the maximum allowed for class F motors, although the 40°C variation within the group can have an impact on motor life.

Another potentially useful performance characteristic not covered by EPACT is current unbalance; the percent unbalance between individual phase currents supplying the motor at rated load when running at balanced (within 0.1 percent) phase-to-phase voltage conditions. This serves as an indicator of electromagnetic nonsymmetry between the phases in a motor. The degree of nonsymmetry depends on many factors, including air-gap eccentricity, voltage unbalance, and current unbalance. Almost all motors have some degree of nonsymmetry; this becomes a problem at levels high enough to induce shaft currents in the motor, which can reduce bearing life. Current unbalance can cause temperature unbalances in individual motor phases.

The average current unbalance of all new AEC-tested motors is 1.1 percent. Current unbalance in the EPACT-related tests suggests that at least one of these motors is outside the normal population distribution of previously tested motors. Two-thirds of the motors exceeded the NEMA-defined maximum starting current, which can contribute to nuisance trips at motor start-up.

Load requirements (and therefore energy consumption) can be significantly affected by the full-load operating speed of induction motors when applied to pump or fan loads. Induction-motor full-load speed is difficult to control in the manufacturing process because it is very sensitive to rotor resistance. Since most induction-motor rotors under 200 horsepower are made of aluminum-die-cast squirrel-cage designs, controlling the rotor-cage resistance exactly is difficult. NEMA allows for a 20-percent variation in the synchronous operating speed implied by the full-load speed listed on a motor nameplate; actual full-load speeds varied from 4 rpm slower than the nameplated value to 8 rpm faster. For 1,800-rpm motors, a 6-rpm speed difference will result in about 1-percent load change on a centrifugal machine. Full-load nameplate speed was within NEMA tolerance for all motors in the EPACT test group.

The results of this study will not be used to certify compliance with EPACT regulations. “Even though the laws are in effect, the rules are still being written, and there won’t be enforcement for a few more years,” Butler said. “As a result, there is more time to become compliant.” The AEC study is primarily for industrial motor users, which have a vested interest in ensuring that the motors they buy comply with all the rules.

“Such information is useful,” Butler added, “because the performance and efficiency of motors with the exact same nameplate information can vary.” (Detailed results of this study, including brand-specific information, are available from AEC.) Ten-horsepower, 1,800-rpm motors are the next group of motors that AEC plans to test.