Energy Tips – Motor Systems

Motor Systems Tip Sheet #4 • September 2005

Industrial Technologies Program

Suggested Actions

- Check shaft alignment of all production critical equipment annually.
- Monitor vibration as an indication of misalignment. Misalignment might be caused by foundation settling, insufficient bolt tightening, or coupling faults.
- After 3-6 months of operation, recheck newly installed equipment for alignment changes due to foundation settling.
- Predictive maintenance techniques, including vibration tests and frequency spectrum analysis, can be used to distinguish between bearing wear, shaft misalignment, or electrically caused vibrations.

Resources

Institute of Electrical Motor Diagnostics (IEMD)—For information on electrical motor diagnostic technologies and motor-system health, visit www.iemd.org.

Electrical Apparatus Service Association (EASA)—Provides information on motor maintenance topics (www.easa.org).

U.S. Department of Energy—For additional information on industrial energy efficiency measures and training, visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices.

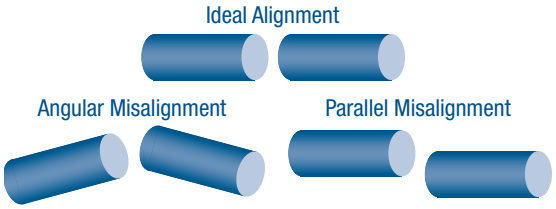
The Importance of Motor Shaft Alignment

The objective of optimized shaft alignment is to increase the operating life span of rotating machinery. To achieve this goal, components that are the most likely to fail must be made to operate within their acceptable design limits.

While misalignment has no measurable effect on motor efficiency, correct shaft alignment ensures the smooth, efficient transmission of power from the motor to the driven equipment. Incorrect alignment occurs when the centerlines of the motor and the driven equipment shafts are not in line with each other. Misalignment produces excessive vibration, noise, coupling and bearing temperature increases, and premature bearing or coupling failure.

Types of Misalignment

There are three types of motor misalignment:



Angular misalignment occurs when the motor is set at an angle to the driven equipment. The angle or mismatch can be to the left or the right, or above or below. If the centerlines of the motor and the driven equipment shafts were to be extended, they would cross each other, rather than superimpose or run along a common centerline. Angular misalignment can cause severe damage to the driven equipment and the motor.

Parallel misalignment occurs when the two shaft centerlines are parallel, but not in the same line. They are offset horizontally or vertically (or both), displaced to the left or right, or positioned at different elevations.

Combination misalignment occurs when the motor shaft suffers from angular misalignment in addition to parallel misalignment.

Couplings

Larger motors are usually directly coupled to their loads with rigid or flexible couplings. Rigid couplings do not compensate for any motor-to-driven-equipment misalignment while flexible couplings tolerate small amounts of misalignment. Flexible couplings can also reduce vibration transmitted from one piece of equipment to another, and some can insulate the driven equipment shaft against stray electrical currents. Even flexible couplings require a minimal alignment, defined in the instruction sheet for the coupling.

It is a mistake, however, to take advantage of coupling flexibility for excessive misalignment, as flexing of the coupling and of the shaft will impose forces on the motor and driven-equipment bearings. Effects of these forces include premature bearing, seal, or coupling failures, shaft breaking or cracking, and excessive radial and axial vibrations. Secondary effects include loosening of foundation bolts, and loose or broken coupling bolts. Operating life is shortened whenever shafts are misaligned.

Alignment Tolerances

Proper shaft alignment is especially critical when the motor is operated at high speeds. Typical alignment tolerances are summarized in Table 1.

Table 1. Alignment Tolerances

Motor Speed, RPM	Parallel Offset (mils)		Angular Misalignment (mils)	
	Excellent	Acceptable	Excellent	Acceptable
1200	+/- 1.25	+/- 2.0	0.5	0.8
1800	+/- 1.0	+/- 1.5	0.3	0.5
3600	+/- 0.5	+/- 0.75	0.2	0.3

In practice, proper alignment is difficult to achieve without using alignment equipment such as dial indicators or laser alignment tools to check and correct for misalignment. The proper shaft alignment procedure is to secure the driven equipment first, and then install the coupling to the equipment. Moving a pump, for instance, would impose stress upon the connecting piping. Then the motor should be moved into proper alignment and joined to the coupling.

After the equipment has operated long enough to become temperature stabilized, shut it down and immediately recheck alignment. Due to thermal growth, machines that are aligned in the "cold" pre-operating condition are almost always out of alignment when operating temperatures are attained. Many equipment manufacturers publish thermal offset values so the alignment professional can correct for thermal growth during the initial alignment process.

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
(1-877-337-3463)
www.eere.energy.gov

Industrial Technologies Program
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121
www.eere.energy.gov/industry

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DOE/GO-102005-2020
September 2005
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