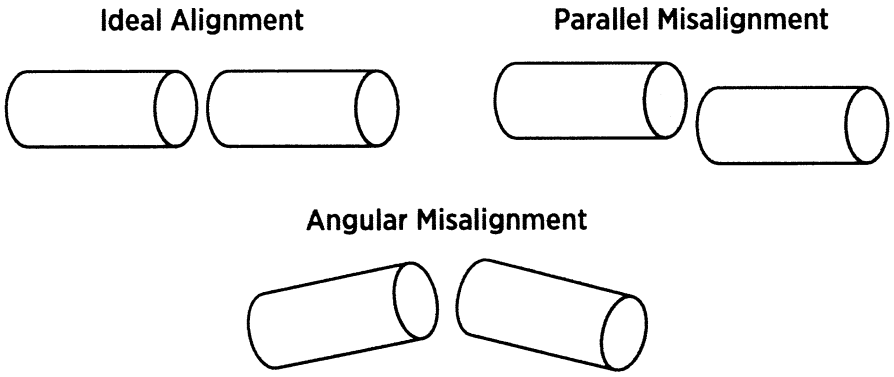
The Importance of Motor Shaft Alignment

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, coupling, or shaft failure.

Types of Alignment



There are three types of motor misalignment:

- Angular misalignment occurs when the motor is set at an angle to the driven equipment. 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. The "gap" or difference in slope of the motor shaft when compared with the slope of the stationary machine shaft can have horizontal misalignment, vertical misalignment, or both. Angular misalignment, in particular 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. There are two planes of parallel misalignment as shafts may be offset horizontally (displaced to the left or right), vertically (positioned at different elevations), or both.
- 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 also can 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 have alignment requirements, defined in the instruction sheet for the coupling.

Suggested Actions

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

However, it is a mistake to rely on coupling flexibility for excessive misalignment, because flexing of the coupling and of the shaft will exert forces on the motor and driven-equipment bearings. These forces may result in 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 when shafts are misaligned.

Alignment Tolerances

No industry standard on alignment exists. Proper shaft alignment is especially critical when the motor is operated at high speeds. Standard industry norms for alignment tolerances are cited in Table 1.

Table 1. Shaft Alignment Tolerances for Direct-Coupled Shafts

Motor Speed (RPM)	Parallel Offset (mils) Short Flex Couplings		Angular Misalignment (mils per inch) Spacer Couplings	
	Excellent	Acceptable	Excellent	Acceptable
900	3.0	6.0	1.2	2.0
1,200	2.5	4.0	0.9	1.5
1,800	2.0	3.0	0.6	1.0
3,600	1.0	1.5	0.3	0.5

Source: Alan Luedeking, Ludeca, Inc. "Shaft versus Foot Alignment Tolerances: A Critique of the Various Approaches," 2008.

In practice, proper alignment is difficult to achieve without using alignment equipment such as dial indicators or laser alignment tools. The proper shaft alignment procedure is to secure the driven equipment first because moving a pump, for example, would stress the connecting piping. Next, install the coupling to the driven equipment. The motor should then 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" preoperating condition are almost always out of alignment when operating temperatures are attained. Many equipment manufacturers publish thermal offset values so the alignment technician can correct for thermal growth during the initial alignment process.

Resources

Electrical Apparatus Service Association (EASA)—Visit www.easa.com for information on motor maintenance topics.

U.S. Department of Energy (DOE)—For more information on motor and motor-driven system efficiency and to download the MotorMaster+ software tool, visit the Advanced Manufacturing Office (AMO) website at *manufacturing.energy.gov.*

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

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