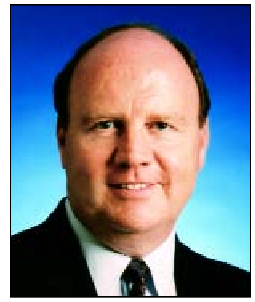
Ross Mackay, Contributing Editor



Shaft Alignment

When it comes to the topic of alignment, let's accept the fact that "coupling alignment" is a misnomer. We are not concerned about bringing coupling halves into alignment—we're only interested in ensuring that the shafts of the pump and its driver will rotate on a common axis. If the shafts are not coaxial, the resulting moments will increase the forces on the pump shaft and bearings, causing accelerated wear and premature failure.

In most installations, it's accepted that perfect shaft alignment is unlikely throughout the operating cycle. In such conditions, the coupling selection should be able to accommodate the maximum amount of the misalignment anticipated. This should be confirmed with the coupling supplier, as even flexible couplings have limitations that are often ignored, resulting in premature bearing failure and unreliable operation.

Shaft Offset and Angularity

Alignment occurs when two lines that are superimposed on each other form a single line. Misalignment is a measure of how far apart the two lines are away from forming that single line. The two lines we're concerned with here are the centerlines of the pump shaft and the driver shaft. In one condition, the two lines can be parallel with each other, but at a constant distance apart. This is referred to as *offset* or *parallel misalignment*. In the other, one line will be at an angle to the other. This is referred to as *angular misalignment*. (See Figure 1.)

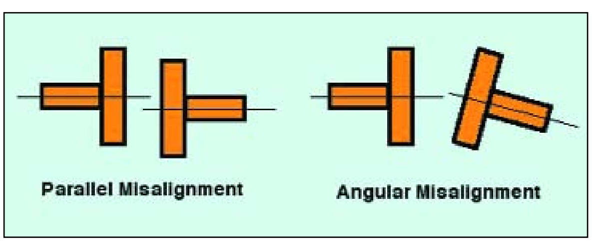


Figure 1. Diagram of shaft offset and angular misalignment

Parallel misalignment can be considered as the distance between the driver shaft centerline and the pump shaft centerline at any given point along the length—and it can happen in any plane. Consequently, it is worthwhile to take the necessary measurements on the top and on the bottom for vertical offset, and also on each side for the horizontal offset.

Angular misalignment refers to the difference in slope of the two shafts. If the pump, base and foundation have been properly installed, the shaft centerline of the pump can be considered as level, and therefore, as the reference or datum line. The slope of the driver shaft can be calculated by determining the offset measurement at two different points, subtracting one from the other, and dividing the result by the axial distance between the two points. (See Figure 2.) This misalignment should be measured and calculated in both the vertical and horizontal planes

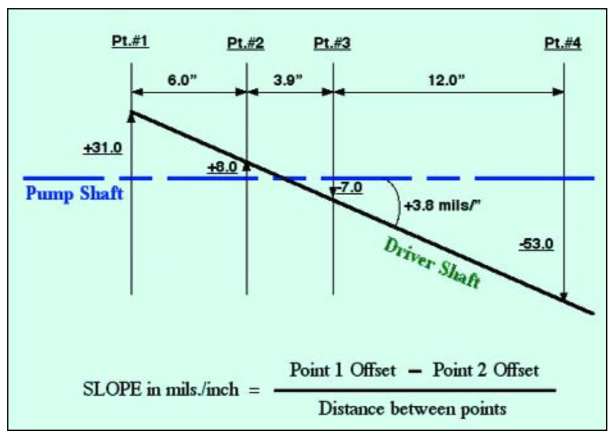


Figure 2. Angular misalignment calculation

High Temperature Corrections

When a foot-mounted process pump must operate at elevated temperatures, some adjustment will be necessary to allow for the thermal growth that takes place between the cold condition and the high operating temperatures. As the pump heats up, the shaft centerline will be moved up, creating an offset with the motor shaft.

One method of handling this situation is to misalign the motor by the amount of growth anticipated from the pump prior to starting it up. Most pump manufacturers can provide the cold setting figures corresponding to the higher operating temperatures. This will require the pump and motor shafts to run in a misaligned setting until the pump is fully up to temperature, by which time, the expansion of the pump will raise it into position to align with the motor.

A second method is to start the pump and motor following a cold alignment, without any adjustment. As the pump heats up and expands, it will gradually move up, out of alignment with the motor. When the pump is fully up to temperature, the unit is stopped and *hot alignment* takes place.

For both of these methods, a flexible coupling, capable of accommodating the total amount of anticipated misalignment, will be required.

Typical Acceptance Values

Bringing the motor shaft into alignment with the pump shaft usually involves moving the front and rear feet of the motor, vertically and horizontally, until the shafts are aligned within acceptable tolerances.

In addition to their dependency on data such as speed of rotation, horsepower, spacer length, shaft size, etc., acceptable alignment tolerances also depend, to a large extent, on the level of reliability the pump user expects. Accordingly, every end user should develop acceptance levels that provide their particular desired outcomes.

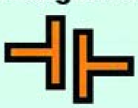
Condition	R.P.M.	Tolerances
Parallel Misalignment 	3600 1800 1200	0.002 ins 0.004 ins 0.005 ins
Angular Misalignment 	3600 1800 1200	0.004 ins/inch 0.006 ins/inch 0.008 ins/inch

Table 1: Alignment tolerances

The tolerances in Table 1 are not intended as definitive values, but can be used as a starting point for developing tolerances that will be specific to an individual company or equipment. They represent the maximum allowable deviation from the desired value, whether that value is zero or a targeted misalignment to allow for thermal growth of the equipment.

Runout

With the coupling disconnected, mount the magnetic base of the dial indicator to the motor half coupling, position the indicator on the pump half coupling and center the indicator plunger. Rotate the pump shaft until the dial indicator reaches a maximum travel, then zero the dial indicator. Rotate the pump shaft again until the dial indicator reaches a maximum value. This shows the amount of runout.

If the runout on the pump side is in excess of the acceptable limit of 0.002”, the pump shaft runout should be checked as above, except with the dial indicator applied to the shaft. If the shaft runout is 0.001” or less, the shaft can be considered acceptable, but the coupling is eccentric. If, however, the shaft runout is greater than 0.001”, the shaft should be straightened. By switching the position of the dial indicator, the driver shaft can be checked in the same manner with the same limitations.

Soft Foot

To check for soft foot prior to alignment, when there are no shims under the motor feet, start by trying to fit a 0.005” shim under each foot. If the shim fits under a foot, make up the gap by gradually increasing the shim thickness until a tight fit is achieved. If shims are already in place, ensure that there are no more than four of them in any one location. If there are, consolidate them by using thicker shims. Check at each foot for loose shims and make up the gap by gradually increasing shim thickness until a tight fit is achieved at all feet.

A final soft-foot check should be performed only after any vertical angular misalignment has been corrected. When that has been achieved, mount the dial indicator to contact the foot to be checked and set the indicator to zero. Loosen the hold-down bolt on that foot and record the dial indicator reading, then retighten the hold-down bolt. Repeat this process with all four feet.

Soft-foot conditions in excess of 0.002” should be corrected by adding shims to the foot with the largest soft-foot value. Note that excess shims will result in increased soft foot at the other feet. Check other feet and make any necessary corrections.

But, Let’s Be Practical. While dial indicators are still a viable method of establishing shaft alignment, laser alignment systems are now providing increased accuracy that reduce maintenance costs while improving reliability. In today’s workplace, where fewer people are expected to do more, these systems reduce the time it takes to achieve a high level of accuracy—and do so without the need for mathematical graphing and calculating expertise.

P&S

Ross Mackay specializes in helping companies increase their pump reliability and reduce operating and maintenance costs through consulting and education. He is the author of the forthcoming book “The Practical Pumping Handbook”, and can be reached at 1-800-465-6260 or through his web site at www.practicalpumping.com