

## Precision Shaft Alignment: What's the Right Method For You?

Written by Daus Studenberg, Ludeca, Inc.  
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It is no secret—precise shaft alignment will pay for itself. It reduces bearing and seal damage, minimizes energy loss, and reduces production downtime. To neglect it would be like failing to perform regular oil changes on your car. You could get by without it in the beginning, but it could cost you a lot of money down the road.

Not only is precise shaft alignment essential, but doing it in the least amount of time is also desirable. Machinery downtime will cost your facility money, especially if that piece of machinery is in the critical path of operation. In some situations, downtime could cost your company hundreds of thousands of dollars per hour.

There are many methods currently available for shaft alignment. They can range from "eyeing" it with a straightedge to using a state-of-the-art, five-axis laser-based alignment tool. Which tool to use will depend on your application, tolerances, and the time required to accomplish the alignment job. This article will explore what is required for precise alignment and what tools are available to accomplish the job.

### Aligning shafts

Precise alignment occurs when the centerlines of rotation of two shafts are essentially collinear with each other. The degree to which two machines are misaligned can be determined by examining the amount of offset and angularity that exists between them. Offset is essentially the distance between the two rotational centerlines while angularity is the angle between the centerlines that is created by the misalignment of the two centerlines.

Is it necessary to get a perfect "zero" offset and a perfect "zero" angularity? The answer is no, because it is only necessary to arrive within the specified tolerance for offset and angularity. See table "[Recommended Tolerances](#)."

The higher the rpm of a piece of machinery, the tighter the tolerance must be. The tolerances table specifies an excellent and an acceptable (or fair) tolerance for both offset and angularity. The acceptable standard is used for re-alignments on noncritical machinery, or where time is of the essence. New installations and critical machines should always be aligned to the excellent standard. In fact, align all machines to the excellent standard if you are not extremely pressed for time.

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For example, a machine turns 1800 rpm, and the shaft alignment measured 1.7 mils for the offset and 3.5 mils per 10 in. for the angularity. The alignment can be left as is because it falls within tolerance. The offset is within excellent tolerance and the angularity is within acceptable tolerance. It would be ideal to get the gap within the excellent tolerance, but if that is not possible, the acceptable tolerance would be OK.

Of the many methods available to measure shaft alignment, the two most popular are dial indicator alignment and laser alignment.

### Dial indicator alignment

Alignment by dial indicator is an accurate method provided these potential problems that can adversely affect readings are dealt with correctly:

- indicator bar sag
- indicator hysteresis (internal friction causing the indicator to stick)
- low resolution
- reading errors (such as not following the indicator travel properly and misinterpreting the sign (+/□) of the reading, or a parallax error from not having the indicator mounted perpendicular to the indicating surface)
- play in mechanical linkages
- components the indicator touches magnetized by an exciter
- shaft axial play (endfloat)
- vibration from surrounding running machinery

Provided that you can properly control or compensate for all of these factors, dial indicators can allow for accuracies of up to 1 mil (1/1000 in.).

Dial indicators are used in various methods to measure offset and angularity; the two most popular methods to be discussed will be the rim and face method and the reverse indicator method. These methods have their relative strengths and weaknesses in terms of convenience and accuracy.

The rim and face method takes an offset reading with a radial indicator and measures the

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angularity with an axial (or face) indicator. Measurement error increases if the rotational diameter at which measurement takes place is 8 in. or less due to decreasing measurement resolution of the angularity, or if shaft endplay exists. One advantage of this method is that it eliminates the need for the indicators to travel through the bottom, which is important where radial clearance is an issue, given that results can be obtained with only three out of four readings over a 180 deg rotation across the top.

The reverse indicator method measures offset at two different locations along the axis of the shafts, thereby allowing the angularity to be calculated. The advantage of this method is that it is less affected by end float. For acceptable accuracy, the distance between the dial indicators must be greater than 8 in. This method requires full rotational and radial clearance all the way around, since the indicators are mounted 180 deg apart from each other. Even a 180 deg rotation will always cause one indicator to travel through the bottom.

If used correctly, dial indicators can be an effective means of shaft alignment. In addition to the previously mentioned factors which can adversely affect indicator readings, do not forget that one still must calculate the offset and angularity values at the coupling center from the raw dial indicator readings at a different location on the shafts and then use this data to calculate the foot corrections to get them aligned precisely. Performing this in the field and then retaking measurements can be a very time-consuming and error-prone process.

### **Laser alignment**

The other popular method for precision shaft alignment, laser alignment, offers the potential for much greater accuracy than dial indicators, with the added convenience of good time savings.

There are several laser systems available. Some use a single laser and detector configuration, one uses a reflected beam approach, and some use a dual laser configuration which works much along the same principle as the reverse dial indicator method. A good laser alignment system should have an accuracy of at least 0.0001 in. (1/10000 in.).

One system works by attaching a laser emitter to one shaft and a position detecting sensor/receiver to the other shaft. Both the laser and receiver are separately mounted to the shafts by means of a rigid bracketing system. Both shafts can remain coupled together. Measurement occurs by rotating the shafts in a continuous sweep as little as a quarter turn (or less), or by rotating the shafts to any desired positions, or to specific clock positions.

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One important feature of the laser-based systems is that they will do the number crunching for you. This means foot corrections and alignment data at the coupling are provided instantly. Some systems even have a soft-foot function that allows users to check for a soft-foot condition, and one will even suggest corrections. Laser systems also let you accommodate much longer spans than dial indicators with great ease (which is necessary for cooling tower fans or cardan shaft drives, for instance) and one will even let you turn the shafts independently when uncoupled.

### Choosing a laser system

Not all laser-based systems are the same. For accurate and repeatable measurements, quality is absolutely essential. The tool must withstand the rigors of the field and be flexible enough in its functionality and features to permit aligning the many combinations of machinery and coupled shafts that exist in the field. It also must be user friendly so the operator can concentrate on getting the alignment right, instead of working to figure out how to operate the system.

Choose a system that is compact, lightweight, but shock resistant, waterproof (at least IP-65), and very rugged. Excellent bracketing is a must. Flimsy or heavy bracketing could shift or distort during rotation. This could cause an inaccuracy in the measurements. Large laser and sensor heads could prove difficult to use in situations with limited clearances or obstructions to rotation.

The laser alignment system should be durable. In an industrial environment, users most likely will be working with temperature and humidity extremes. There is also a possibility of noisy electrical conditions as well as sprays from liquids. Make sure the unit is capable of operating in this type of environment. With such existing conditions, there is also the risk of an operator accidentally dropping a component of the unit.

Finally, make absolutely certain the system offers a range extension feature and the ability to independently enter target specifications for thermal growth as well as thermal growth values at the support points of the machine. It should offer the ability to recalculate corrections when you get bolt-bound (a static foot function) for all machine feet. If you have machine trains (three or more machines) make sure the system can handle the whole train and display results for all together. The tool must tell the operator when he has arrived within tolerances, and these tolerance parameters should be controllable by the user. Documentation is critical. Only the best systems will let you store a file, reopen it, continue working, and print a report.

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Laser alignment systems have advantages over dial indicators. The main disadvantage may be in the up-front cost of the system. Laser alignment systems can range from \$3000 to near \$20,000, with the best systems costing upwards of \$12,000. When time savings, reduced downtime, increased reliability, fewer repair costs, and lowered electricity costs are all considered, a high quality laser alignment system is easily one of the best and fastest paying investments to be made in the maintenance department. **MT**

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Information supplied by [Daus Studenberg](#), applications engineer, at [Ludeca](#), Inc., 1425 NW 88th Ave., Miami, FL 33172; telephone (305) 591-8935

Recommended Tolerances

Offset (mils)

Gap (mils/10 in.)

	RP	Excellent	Excellent	Excellent
600	5.0	9.0	10.0	15.0
900	3.0	6.0	7.0	10.0
1200	2.5	4.0	5.0	8.0
1800	2.0	3.0	3.0	5.0
3600	1.0	1.5	2.0	3.0
7200	0.5	1.0	1.0	2.0

[return to article](#)