# Debunking laser shaft alignment

by Victor Wowk, P.E.

***There are three major measurement systems to achieve shaft coaxiality on coupled machines, when they are stopped. These are*:***

***1. Feeler gauges and straight edges***

***2. Dial indicators***

***3. Laser systems***

This article is an attempt to set the record straight about laser systems, which have been grossly oversold. They have been oversold from several perspectives. First, they do not leave the machine in any better final condition than dial indicators would, when the laser is properly used. When improperly used, lasers can leave the machines in a grossly misaligned condition, and the craftsperson gets no reliable feedback that this is the case. Dial indicators can achieve just as precise a final alignment as any other known instrument or method, including lasers. For some machines, like long drive shaft, heavy machines, and large couplings, dial indicators will leave the machine shafts in a better orientation.

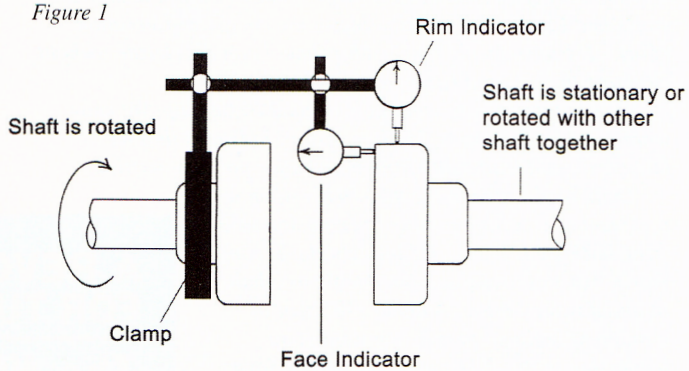
Second, lasers cost far too much for the hardware that is acquired. Some laser systems cost as much as a new car. The amount of hardware, software, and R&D development effort just does not justify the cost. In this context, they have been oversold because people have paid more than they are worth. In addition, they cost far too much to maintain.

Third, laser systems have been oversold to people who do not use them correctly. Some users do not read the owner's manual supplied and fail to make the proper setups, and stumble and get confused when things do not flow smoothly. It is a mistake to compensate for low craft skill with a high-tech tool. The craftsperson would do better with dial indicators or straight edges which provide a direct indication. These instruments are less abstract and more straightforward. Dial indicators display to the mechanic when things are not right and no more interpretation is required.

Fourth, engineers have a misconception that "laser alignment" is better, and specify that the machines be "laser aligned." This displays a lack of knowledge of the alignment task. It is a mistake to specify tools rather than results. An analogous situation would be for me to require my auto mechanic to use electronic torque wrenches to repair my car. Rather than the tool used, the desired final condition should be specified. The knowledgeable craftsperson can then select the appropriate tool for the task. In this context, misguided engineers have driven the purchase of laser systems, and have not served their profession well. Maintenance engineers and managers who are responsible for expensive machines need a fundamental understanding of alignment methods.

Fifth, lasers do less than dial indicators. Dial indicators can do everything that lasers can do for shaft alignments, plus a whole lot more. This is the purpose of this article—to point out where lasers fall short and are useless. Being oversold in this context means that the buyer bought a partially filled box of goods and paid dearly for it. This demonstrates the power of salesmanship.

*Figure 1*




## Face-and-rim

Lasers can only do reverse-indicator alignment methods. The second major alignment method, face-and-rim, can only be done with relative displacement gauges like dial indicators or proximity probes. No laser system that I am aware of can do face-and-rim alignment.

Face-and-rim alignment for shafts is necessary when one machine cannot be rotated. Some machines have so much inertia, or rolling resistance, that they cannot be rotated. In this case, the coupling must be disengaged, and the shaft alignment done using the face-and-rim method, while fixtured on the rotating shaft and reading on the stationary shaft.

In my experience around common machines, face-and-rim alignment needs to be done about 15 percent of the time. On large, or heavy machines, face-and-rim is the preferred method because of the geometry and because of shaft sag. The favorable geometry is the large swing diameter of the face reading on large-diameter couplings. This produces a more sensitive indication of angularity. Shaft sag on heavy machines produces an angularity of the faces of adjacent couplings. Imagine a heavy weight center suspended on a flexible shaft. The center of the shaft will sag down in a gravity field and the portion of the shaft outboard of the bearing will deflect up. The bearing acts as a fixed pivot point. With an upward deflection, there will be an angularity between the faces of adjacent couplings, even though the bearings are in perfect bore alignment. Lasers cannot help us here, and in fact they will leave the couplings in a distorted

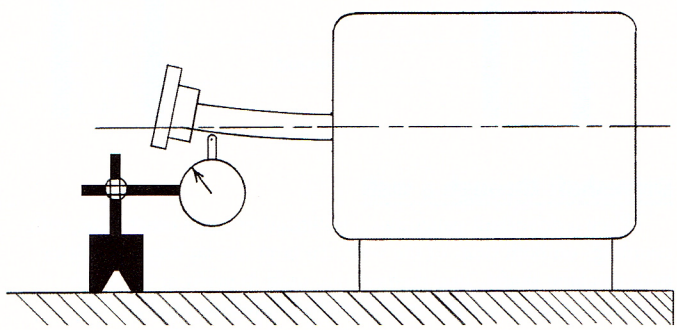
** Running alignment will not be discussed here.*

condition with reverse-indicator alignment methods. A face reading with a dial indicator can easily detect this angularity and the machines can be positioned with the faces of the coupling parallel, hence less distortion during rotation. This is why the largest and heaviest machines are still preferably aligned with dial indicators using the face-and-rim method.

A face reading is the only way to set a vertical spindle perpendicular to a table. It is the most general method for aligning precision rotors to be perpendicular to some other surface. Lasers are useless for this task.

In terms of shaft-to-shaft, all shafts can be aligned with dial indicators using the reverseindicator or face-and-rim methods. If I had only a laser instrument then I can onlyuse the reverse-indicator method, which means that some jobs could not be done.

*Figure 2*



## Shaft runout

Lasers cannot measure shaft runout. Some precision optical gages can measure shaft runout, but the laser systems sold for shaft alignment cannot. Runouts are a major feature that need to be gaged for proper machine commissioning, and for diagnosis when there is excessive vibration. Measuring shaft runout is a common preliminary task for shaft alignment, and every person responsible for machines, whether alignment, balancing, or repair, should have a way to measure shaft runout. This is easy to do with a dial indicator. Laser shaft alignment systems cannot measure runout.

To do a thorough machine setup, of which shaft alignment is only a portion of the task, the alignment of other components, like couplings, pulleys, and gears, sometimes needs to be checked. Universal test indicators with magnetic bases are up to the task. Lasers need to sit on the bench for this play.

*Figure 3*

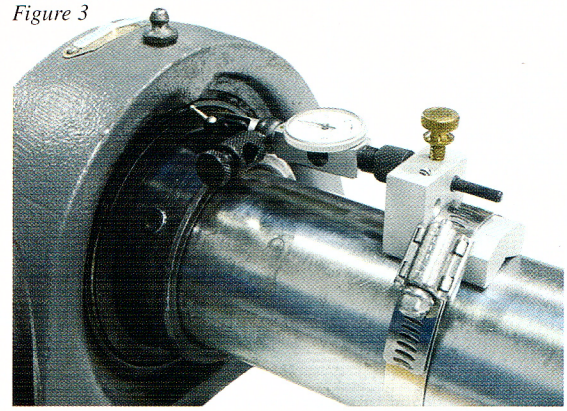
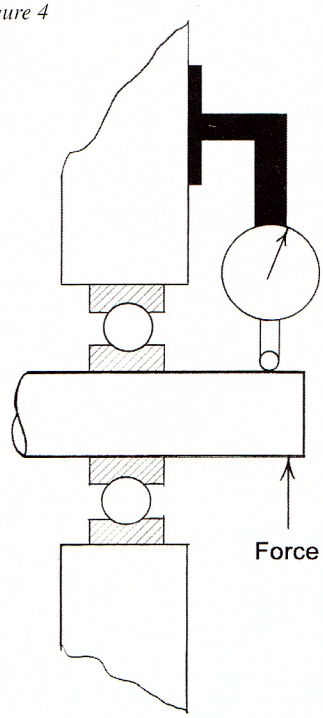


*Figure 4*




## Bearing alignment

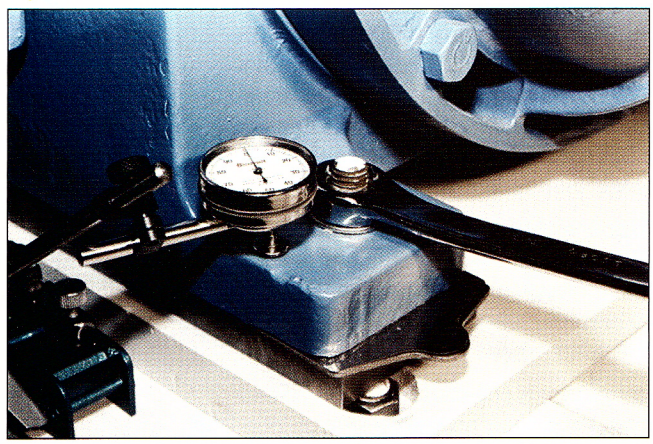
Measuring the squareness of a bearing ring to the shaft rotation axis is basically a face reading. I mention bearing alignment because it is a major cause of bearing failures, preceded by vibration, noise, and temperature. This is a simple task for a universal test indicator if the bearing rings are accessible and the proper fixturing to the shaft is used, like a small V-block. This is a lost skill in the maintenance trades, but a necessary skill among precision machine builders. Lasers, again, must sit this one out.

## Bearing clearance

The lift test with a dial indicator is commonly used to measure the clearance in plain bearings and to gauge the wear in rolling-element bearings. Thickness gauges could also be used if the space is accessible. For a lift test, or a push test on vertical shafts, all that is needed is an exposed shaft, a dial indicator on a magnetic base, and a pry bar.

Instruction manuals for lasers are peculiarly silent on how to do this bearing-clearance test, and the preceding three measurements.

*Figure 5*

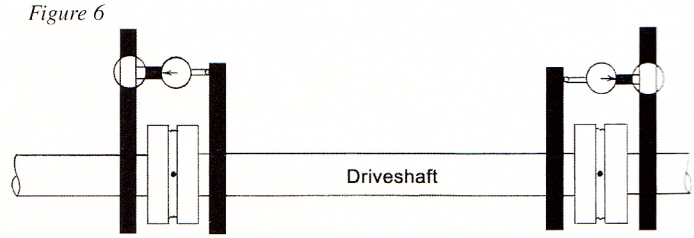


## Soft foot

Laser measurement systems mounted on the shaft can indirectly measure the motion when hold-down bolts are loosened, just like dial indicators mounted on the shafts can do. But lasers cannot measure directly the rise at the feet, which dial indicators can. The foot will remain still or rise whenever a hold-down bolt is loosened. If you ever see a dial indicator read negative as a hold-down bolt is loosened, call me immediately at (505) 884-9005. You have observed a physical phenomenon that violates the laws of physics and I want to investigate.

In fact, machine casing distortion in general, is better measured directly with short-range dial indicators. The one exception where lasers are useful is to span the distance across the coupling and measure relative housing motion with the source and detector fixtured to the housing as the machines are started (please remove your laser heads off the shafts prior to startup). This has been used to detect gross mechanical motion on startup caused by torque reactions, loose or unstable foundations, and other unknown motions not detectable by any other method.

*Figure 6*




## Driveshaft through a wall

When a driveshaft penetrates a bulkhead or some other hole, with couplings on both sides of the wall, the laser has no line-of-sight to both machine shafts. Two methods are used to perform this shaft alignment task—the rim-rim or face-face Forcados method. You will need two laser systems to do the rim-rim method, or move your laser system from one coupling to the other repeatedly. Lasers cannot do the face-face method at all. Most dial-indicator systems have enough parts to do either the rim-rim or face-face method with no additional clamps or fixturing required.

## Explosive environments

Dial indicators are intrinsically safe, they require no electrical power and cannot generate a spark. Not so for all laser systems.

## Conclusion

The laser and dial indicators are only measurement tools. They represent a portion of the total alignment task, which includes moving the machines, dealing with bolt-bound and height-bound conditions, assessing distortion, and dealing with other complicating factors like pipe strain. But if it was a perfect world and I only had to do a simple shaft-alignment job with no complicating factor to entertain me, then either tool would work and achieve equivalent results in terms of shaft coaxiality. The laser costs much more but does less. It also costs much more to maintain. From a business perspective, it is a poor choice for making a profit. For the cost of one laser system, I could purchase several dial-indicator systems. If I had several qualified technicians to dispatch, then my business could bill more alignment jobs simultaneously.

Those companies that have purchased laser alignment systems find that they need to keep their dial indicators for those tasks that lasers cannot do. I have even observed the mechanics revert to dial indicators when the laser batteries run down, and then not bother to replace the batteries. Don't discard those dial indicators too hastily.

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*Victor Wowk, P.E., is the author of Machinery Vibration: Alignment, published by McGraw Hill in 2000. He has been aligning machines for about 20 years, and continues to personally align something at least once a month. He teaches a two-day alignment class every February in Phoenix that is open to the public. More information is posted at www.machinedyn.com. Comments on this article are welcome.*